

MARTIAN MYSTERY BLOB
What's that thing in the red sky?

NewScientist

WEEKLY February 21 - 27, 2015

THE WHITE STUFF

**WHY IT'S NOT JUST
YOUR GRAY MATTER
THAT MATTERS**



CAUGHT IN THE ACT

The seven most revealing fossils ever found

SHADY BUSINESS

The dark trade in secrets, leaks and lies

RUNNING ON EMPTY

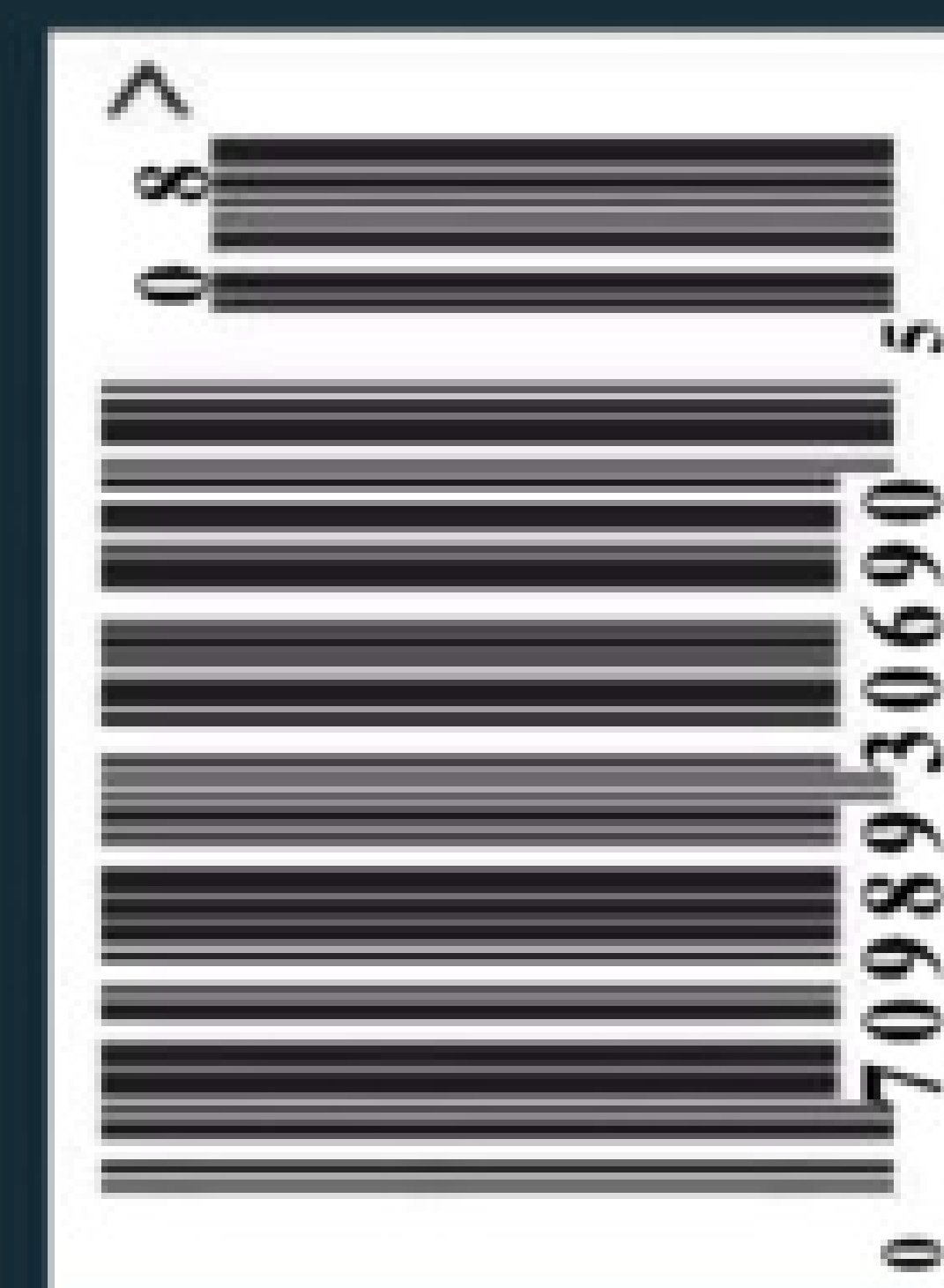
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ARCTIC IN BLOOM

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Like a car. But be



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The new Audi A3 Sportback e-tron.

etter



WHATCAR?
**Car of the
Year 2015**
Best electric car

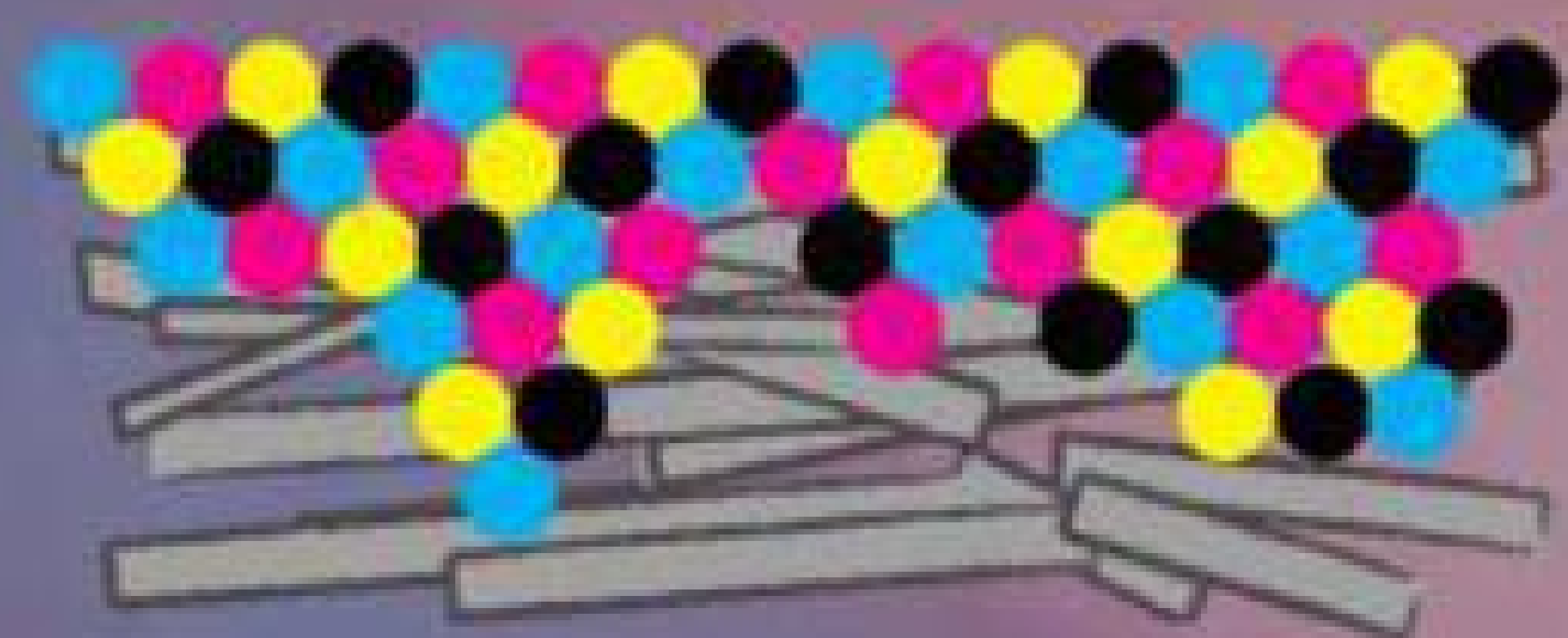
weighted: 176.6 mpg (1.6 litre/100km). CO₂ emissions: 37g/km. The 'Combined/weighted' fuel consumption CO₂ figures calculated from two taking into account mileage range on battery power only, providing a figure in a variety of charge conditions. Extended range achieved by 1.4 TFSI real driving results. Images for illustration purposes.

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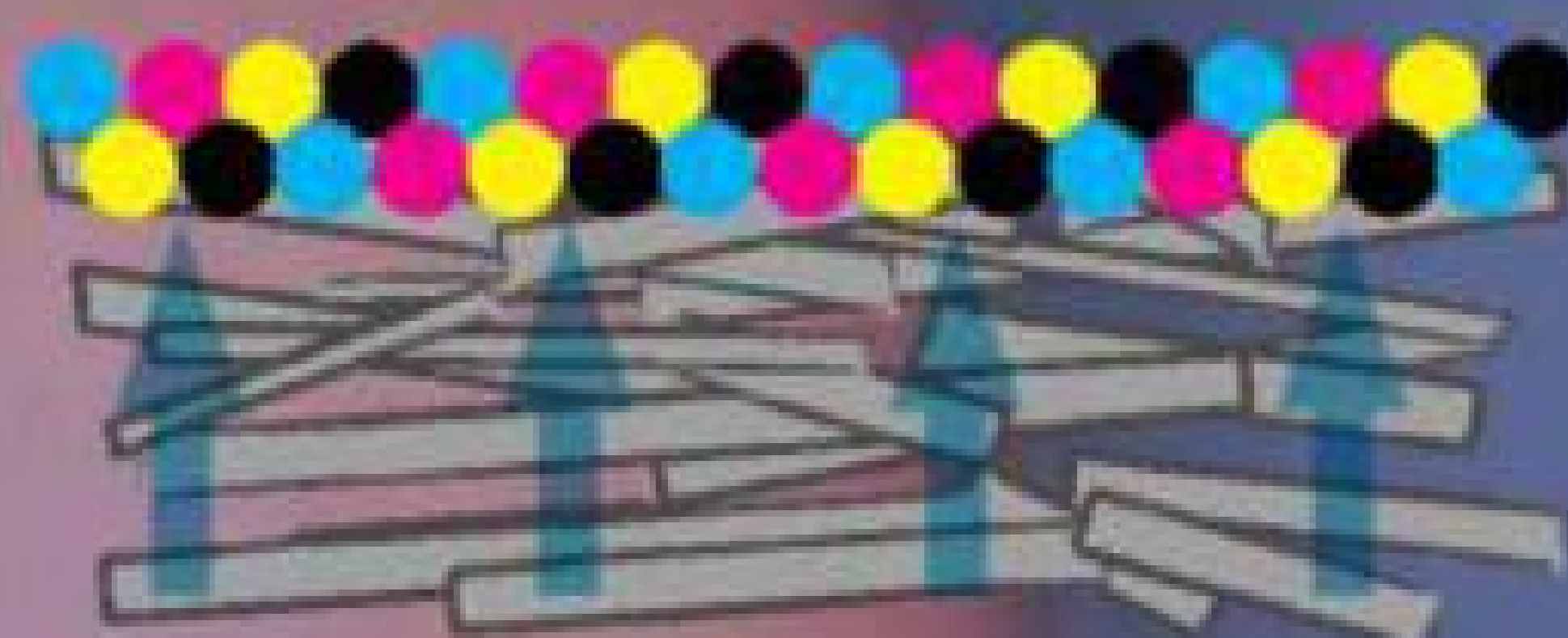
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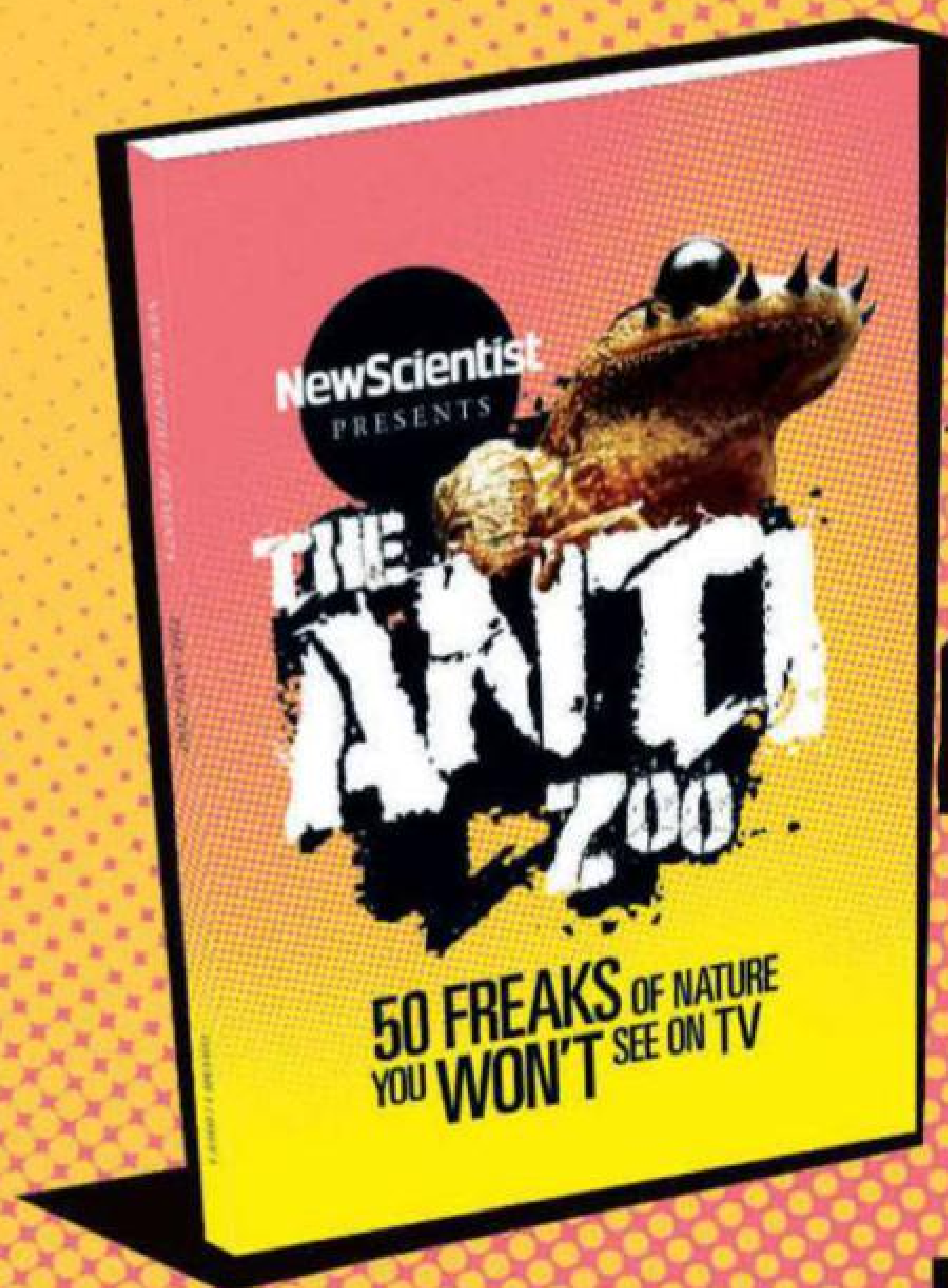
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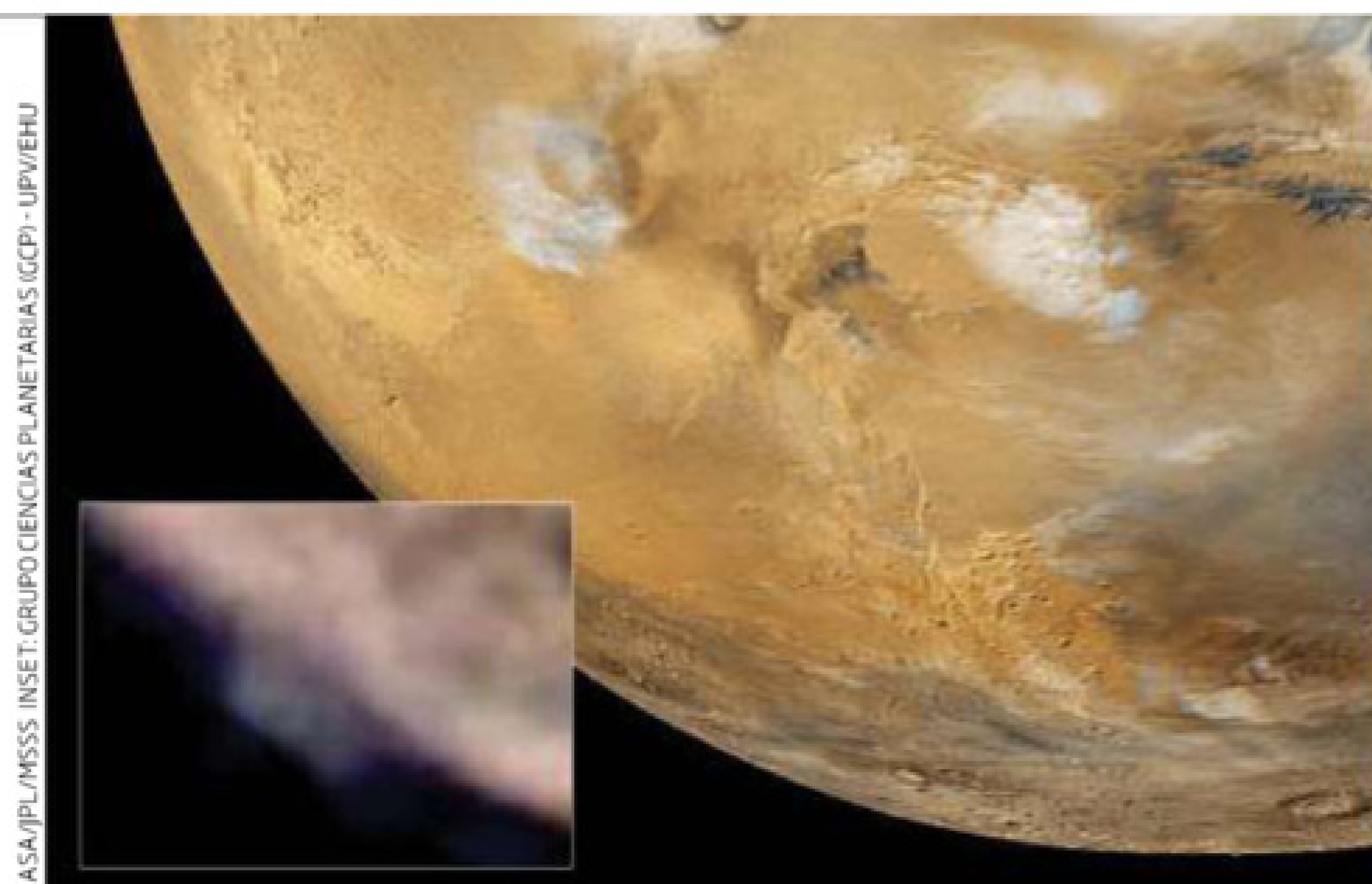
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Mystery blob spotted on Mars

Strange sight has left astronomers groping for an answer



NASA/JPL/MESS INSET: GRUPO CIENCIAS PLANETARIAS (CCP) - UPV/EHU

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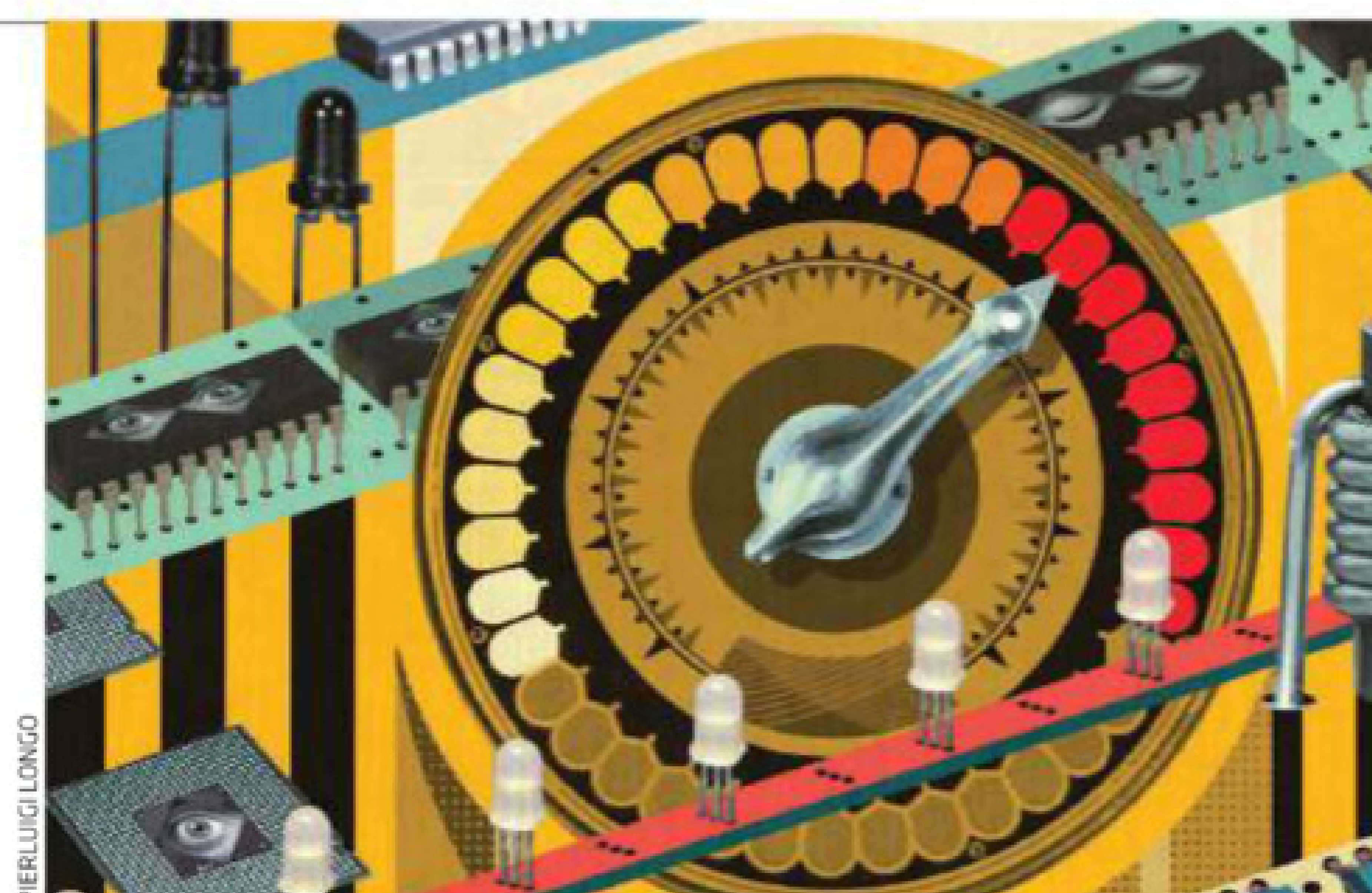
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Faster!

Why high-performance computing is due a reboot



PIERLUIGI LONGO

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The overlooked sense that shapes our lives

Build your own fusion reactor

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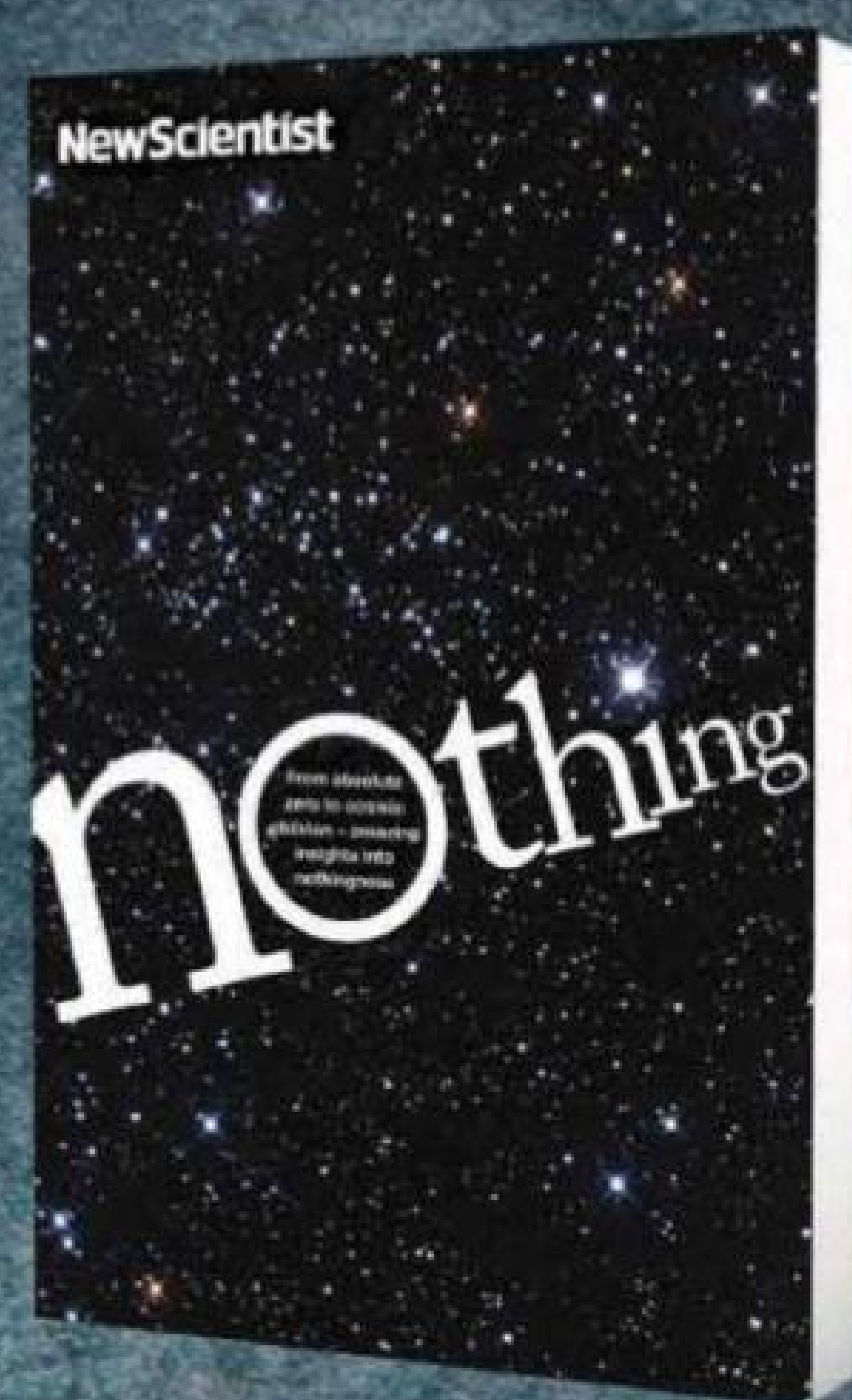
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STEPHEN WEBSTER/PLAINPICTURE

New kid on the blockchain

A market for secrets could start a commercial revolution

HOW much is a secret worth? If you've got one worth selling, you can now find out via an online service called Darkleaks. Its creators describe it as a market for sensitive information, from WikiLeaks-style disclosures to nude celebrity selfies (see page 20).

The rights and wrongs of such a market will be debated long and hard. But Darkleaks is worth watching for reasons other than the beans it will spill.

One of its most notable features is how it allows buyers and sellers to hide their identities. The key to this is the bitcoin blockchain – two words highly likely to make your eyes glaze over. But they are two words that will be increasingly hard to ignore.

In essence the blockchain is a ledger of all the digital currency's transactions: every time a bitcoin, or part of one, changes hands, a record is added to the chain. A copy of the blockchain is held by every computer running bitcoin software, making it a reliable and permanent record. It is the most important feature of the system, as it allows the currency to exist without the oversight of a central authority.

Digital currencies may or may not be the future of money. But the blockchain is another matter entirely. Many technology watchers believe it has the potential to transform the economy. Because adding information to the blockchain is

easy and cheap, it could supersede all kinds of cumbersome systems for keeping records and registering ownership.

Ambitious coders are already imagining an entire economy built on the blockchain, from allowing you to sell your house without lawyers to riding in a driverless car that owns itself. According to one expert, the development of Darkleaks is "a necessary step" towards this.

Communications technologies often find early adopters in seedy industries: where would the internet be without pornography? Darkleaks may have a similar whiff about it, but it could prove to be a quantum leap for blockchain technology. ■

Chilling reminders

WE OFTEN hear that the Arctic is the fastest-changing region on Earth. As the global climate warms, feedbacks such as the loss of heat-reflecting sea ice mean that the Arctic is warming about twice as fast as the rest of the planet – with potential knock-on effects for all of us.

No surprises there; we and other media have been reporting these changes for years. As a

result, they have lost their power to shock or even surprise.

It takes an encounter with somebody who is witnessing the transformation first-hand to bring home just how rapid and profound it is, and what the world is losing as a result.

One such person is marine biologist Antje Boetius, who works in the Arctic year in, year out. Among other things, she

studies the floor of the Arctic ocean, once thought to be a lifeless desert but now known to be anything but (see page 28).

But even as she makes discoveries, the world is shifting under her feet. Change is happening so fast that science cannot keep up, she says.

Sadly, we are now at a point where we can only document the changes in the Arctic. It is important that we not look away, to keep reminding ourselves of the price of failing to act. ■

Italy: a dying country?

WHERE are all the bambini? Italians gave birth to fewer babies last year than at any time since the state formed in 1861. And they are not alone.

In 2014, there were 17 per cent more deaths than births, according to Istat, the national statistics office. Health minister Beatrice Lorenzin warned "we are very close to the threshold of non-renewal... we are a dying country".

Italy's fertility rate - an estimate of how many children an average woman is likely to have - is much lower than the replacement level. Just over 2 children per woman will maintain a population in the long term, but the current rate in Italy is only 1.39. And with a median age of 44.5, it is now the second-oldest country after Japan.

Some media reports blamed the low on the poor state of the Italian economy but some sociologists also point to a macho society that makes it hard for women to both work and bear children. Many choose the former.

But although Italy has the lowest fertility rate in Western Europe, fellow economic struggler Greece has a level of just 1.41 children per woman, and Spain 1.48.

The only reason Italy's population is not already falling is because of the arrival of migrants. The country had a net inflow of more than 200,000 people last year. Most migrants are young: they keep up numbers, offset the country's ageing population, and bolster fertility. Without them, Italy's fertility rate would be only 1.29, says Istat.



An elderly state

Cost of pricey drugs

IF YOUR hernia operation gets cancelled in the UK, the US health system is probably to blame. That's one of the conclusions of a study exploring how the price of new drugs affects the availability of resources and value for money in the UK National Health Service.

The researchers found that, overall, more people suffer than gain if the NHS buys expensive but marginally effective medicines (*Health Technology Assessment*, DOI: 10.3310/hta19140).

The study's co-leader, Karl

"The US invests in drugs with marginal benefits, while the rest of the world is a victim of its prices"

Claxton at the University of York, blames the US, whose healthcare system pushes up prices globally. "It makes high-cost investments in drugs that bring only marginal benefits, and the rest of the world is a victim of the prices in the US healthcare system," he says.

Claxton's analysis found that people using the NHS

are harmed when it buys expensive drugs because resources are taken from elsewhere in the system.

Most controversially, he calculated that the Cancer Drugs Fund, which will have a budget of around £340 million for 2015-16, harms around five times as many people as it helps. Spending on expensive cancer drugs leads to reductions in other cancer services and treatments, such as early diagnosis, high quality surgery and radiotherapy, and many other treatment areas such as mental health and respiratory disease. "There are real effects on real people who will die or suffer as a result of these additional costs," says Claxton.

His team based their study on calculations of how much it costs to keep a person using the NHS alive and in good health for a year - a measure of healthcare costs called a QALY. In 2013-14, the Cancer Drug Fund's budget of £231 million will have gained 3374 of these years for those treated, but 17,821 would have been lost elsewhere as a result of cuts to pay for the pricey cancer drugs.

No let-up on Ebola

IF EBOLA erupts again tomorrow, will we be any better prepared? Only if we improve the way we study, treat and contain the disease, public health officials told the AAAS annual meeting in San Jose, California, last week.

"We have to identify how we will move things forward, so we will have things much more ready to go when the next outbreak occurs," says Michael Kurilla at the National Institute of Allergy and Infectious Diseases in

Bethesda, Maryland. The institute is trying to speed up research by creating a common standard for methodology and materials, making it easier to compare data.

The recent outbreak in West Africa helped develop new approaches that could be reused, such as installing Plexiglas walls so that healthcare workers could check on patients without wearing full protective gear. It also generated a wealth of clinical data about the virus and its long-term effects on survivors that will need further study, the meeting heard.

Should we be contacting aliens?

EARTH phone ET. Instead of listening out for signals from aliens, we should actively direct signals to promising exoplanets where they might live.

So said Douglas Vakoch of the SETI Institute at last week's meeting of the American Association for the Advancement of Science in San Jose. The project to contact aliens is also known as METI - messaging extraterrestrial intelligence.

But others argued that if we alert a super-intelligent race of aliens to

our presence they could come here and harm us. Several space bigwigs, including science fiction author and astrophysicist David Brin, issued a statement last week calling for a moratorium on METI.

There should be public debate about the possible risks before we go ahead, Brin told the meeting. "A worldwide scientific, political and humanitarian discussion must occur before any message is sent," the statement said. Put the phone down!

Climate party

PARTY politics meets climate change. Leaders of the UK's three major parties have agreed that whoever wins the general election in May, Britain will carry through its obligations

"The cross-party pact represents an unprecedented show of party unity"

to try and halt global warming.

The cross-party pact, signed by the leaders of the Conservatives, Liberal Democrats and Labour, represents an unprecedented show of party unity. It comes in the same week that officials from 194 countries met in Geneva, Switzerland, to finalise an initial negotiating text for the upcoming UN climate summit in Paris, France, in December.

The trio vowed to seek a deal in Paris restricting global temperature rises to 2°C, a threshold beyond which climate change would be likely to have catastrophic consequences. "They've agreed this goal is above party politics," says Matthew Spencer, director of the Green Alliance, the pressure group that brokered the cross-party deal. But, he says, they are still to confirm dates and details for their pledges, such as ending emissions from coal and transitioning to an energy efficient economy.



Don't phone home

AP PHOTO



Now with age and speed limits

Laws for drones

DRONE business is looking up – for some. The Federal Aviation Administration (FAA) has released a proposal for laws governing autonomous aircraft in the US.

It might cause problems for Amazon's drone delivery plans. For now, the rules don't permit flight during the night or outside the pilot's line of sight.

In the US, drones have long occupied a legal grey area. Congress has asked the FAA to

"These plans are the first glimpse at what might be legally possible for drones in the future"

come up with comprehensive rules by September this year. The plans released this week are the first glimpse at what might be possible for drones in the future.

Under the proposal, people would be allowed to fly registered drones weighing up to 25 kilograms, provided that they stay below 150 metres, and 160 kilometres an hour. Pilots must also be at least 17 years old, pass an aeronautics test and be vetted by the Transportation Security Administration.

Ella Atkins, an aerospace engineer at the University of Michigan, Ann Arbor, is happy with the proposals. "It's good

news for engineers, scientists and others such as myself who want to use UAVs for research."

Meanwhile, Amazon remains hopeful about future updates to the rule book. "We are committed to realising our vision for Prime Air and are prepared to deploy where we have the regulatory support we need," it said in a statement.

Online courts

SEE you in court! Or how about we just sort things out online?

A report from the UK's Civil Justice Council has recommended that people be able to do just that. It says that the government should set up an online court service as early as 2017 to allow individuals to settle civil cases with a value of £25,000 or less via the web or telephone conferencing.

Chris Wilford, head of policy and public affairs at the Chartered Institute of Arbitrators in London, says the report is a step in the right direction. "The Ministry of Justice budget has been reduced extensively since 2010, so there need to be new ways of dealing with that and preserving access to justice," he says. Wilford also cites improvements in efficiency if technology helps speed up court procedures. "That is definitely a real step forward for people."

Operating room GPS

Take a left at the next eyeball. Doctors are using virtual reality to plan complex operations as well as navigate them for real. A team at Texas A&M University in Dallas used it to restore a man's face, after it was damaged by a rare fungus, by linking the movement of real and virtual surgical tools.

Steppe invaders

Western Europe was stormed by people from the steppes of present-day Russia and Ukraine some 4500 years ago, reveal the genomes of nearly 100 ancient Europeans. These Yamnaya herders domesticated the horse and invented a wheel around 6000 years ago, which allowed them to travel far and import the Indo-European language family into Europe ([bioRxiv, doi.org/z9d](https://doi.org/10.1101/005480)).

Really shocking

A magnitude 6.7 earthquake hit Japan on Tuesday, briefly triggering a tsunami warning. The quake is an aftershock of the one that hit the Tohoku region and damaged the Fukushima nuclear plant in 2011. Such aftershocks could reverberate in the region for the next 100 years.

Dodgy drives

The US National Security Agency (NSA) may have been infecting hard-drive firmware to spy on people in Iran, Russia and other nations, according to Russian anti-virus firm Kaspersky. It has found traces of advanced malware deeply embedded in drives dating back 14 years and says the code is similar to the Stuxnet and Flame malware previously linked to the NSA.

One small, small step

Mars One, the Dutch firm attempting to colonise the Red Planet, has selected 100 potential astronauts to start training for the trip. Now all they need is a few billion dollars, multiple rockets and spacecraft, and the technology to stay alive on a hostile world.

What's flying over Mars...

Could it be auroras? Volcanoes? Even aliens? **Jacob Aron** investigates

WE THINK we know our red neighbour pretty well. The first map of Mars was sketched 500 years ago, and we have sent more than 50 robot explorers to patrol the surface and watch it from orbit. Seven are on the case right this minute. When it comes to Mars, we are not easily surprised.

Hence the shock when, on 12 March 2012, amateur astronomers around the world noticed a strange blob rising from the planet's southern hemisphere, soaring to 250 kilometres above the surface. Nearly three years later, the sighting still defies explanation.

The blob appeared only in the mornings and grew to around 1000 kilometres across in the following 11 days, even stretching a "finger" out into space. "I was really quite amazed that it was sticking out the side of the planet quite prominently," says Damian Peach, who lives in Selsey, UK, and was one of the first to spot it.

Poor weather and other issues

meant no one had their eye on Mars the following week, and by 2 April it seemed to have disappeared. Then on 6 April a second object of the same type emerged from the same spot and lasted another 10 days. It, too, has not been seen since.

Now, in an attempt to pin down the blobs' origins, Agustin Sánchez-Lavega of the University

"Frankly, I'm puzzled. I don't understand how material can get that high and stay there for so long"

of the Basque Country, Bilbao, Spain, and colleagues including Peach, have dug out images of Mars from that period. In the end they amassed pictures from 18 observers equipped with a variety of small telescopes. The team also searched through old images taken by the Hubble Space Telescope and identified a similar object in 1997.

The team considered several

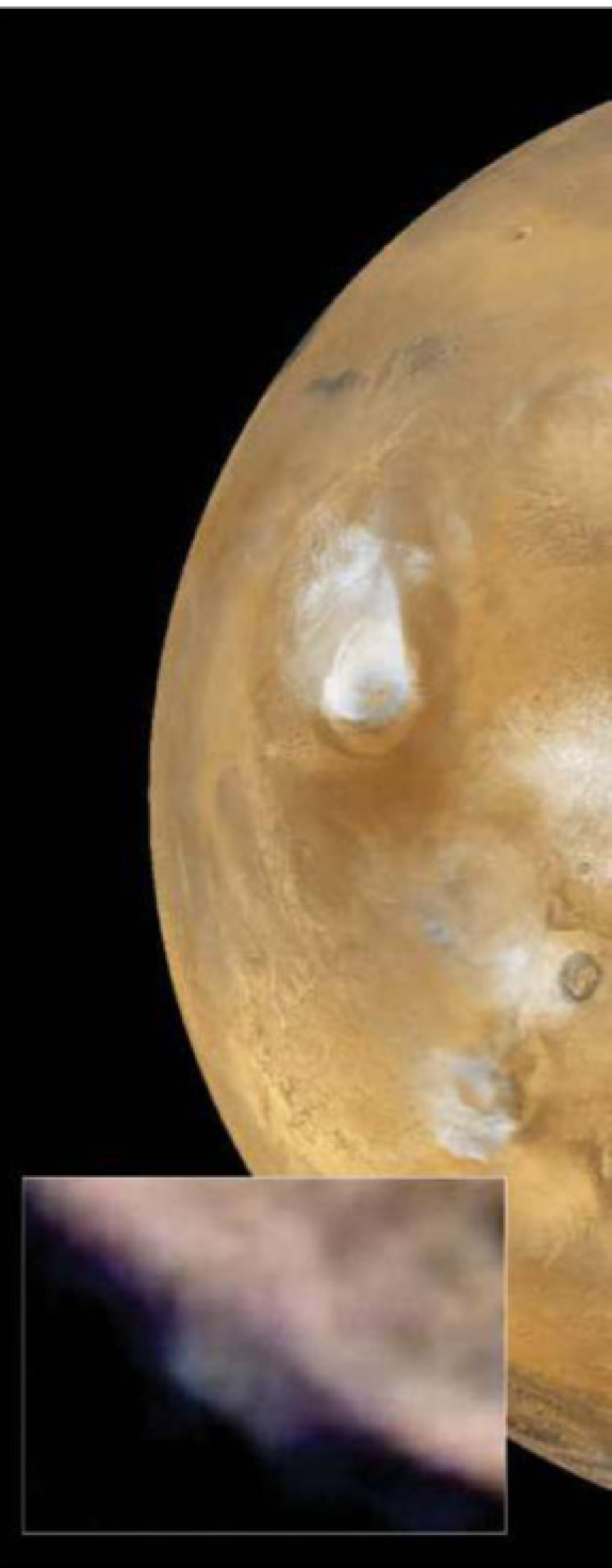
possible explanations, each more exotic than the last. Despite their best efforts, though, they couldn't come up with any that fitted known processes – and neither can anyone else (*Nature*, doi.org/z9j). "Frankly, I'm puzzled by the observations," says Bruce Jakosky of the University of Colorado at Boulder, who leads NASA's Mars-atmosphere-observing MAVEN mission. "I don't understand how material can get that high and stay there for so long."

One clue is that the blobs seemed to appear at Mars's terminator, the fuzzy line where night turns into day. That suggests the source might be a change in atmospheric temperature due to the morning sun. The team's best guess is that the object is a cloud of frozen carbon dioxide and water particles condensing in the upper atmosphere.

If that's the case, it would be unlike any cloud seen anywhere on Mars, or on Earth. Clouds on both planets are only ever seen at altitudes below 100 kilometres, which on Earth is the accepted height for the beginning of outer space. "If the phenomenon is a cloud, then the most similar phenomena on Earth will be the mesospheric clouds that form at 80 kilometres altitude on polar regions," says Sánchez-Lavega.

With that in mind, thoughts have turned to other potential explanations. Charged particles from the sun interact with the Earth's magnetic field to make the upper atmosphere glow – the phenomenon we call auroras. Mars's magnetic field is weak and patchy in comparison, meaning auroras were first seen there when we had a spacecraft in place in 2005. That sighting was over a region tantalisingly close to the unexplained blobs.

NASA/JPL/MSSS INSET: GRUPO CIENCIAS PLANETARIAS (GCCP) - UPV/EHU



The team calculate that the blobs could be auroras, but only if they are more than 1000 times brighter than Earth's. That seems unlikely, especially since the sun wasn't particularly active then.

What if a massive volcano were pumping material into the atmosphere? The blobs seemed to extend upwards from the surface, though it's hard to determine this exactly given the quality of the images we have. But that wouldn't explain why the blobs only appeared in the morning, says Sánchez-Lavega, and in any case we don't know of any active volcanoes on Mars.

"You would think that something large enough to dump that much vapour in the atmosphere would be picked up," says Nicholas Heavens of

THREE MORE MARTIAN MYSTERIES

ANYONE THERE?

You can't talk about Mars without talking about the possibility of life. The latest view, thanks to NASA's Curiosity rover, is that the planet was definitely capable of hosting life in the past – but the jury is still out on whether microbes once thrived there. The ExoMars rover, launching in 2019, might be equipped to give a definitive answer.

WHO DEALT IT?

A related mystery is figuring out the source of short-lived bursts of methane on Mars. Burping microbes are one possibility, but geological processes can also produce pockets of underground methane that might

gradually seep out to the surface. The ExoMars Trace Gas Orbiter will be on the case when it launches in 2016.

CALL THAT A MOON?

Mars has the weirdest moons in the solar system. Phobos and Deimos are lumpy, misshapen rocks, and tiny compared with other planets' spherical satellites. The moons might be captured asteroids shot out of the asteroid belt toward Mars by Jupiter's gravity, or even chunks of Martian crust blasted off the surface by an ancient impact. A Russian mission to land on Phobos in 2011 was meant to bring samples, and answers, back to Earth, but a botched launch means we remain in the dark for now.

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Ok, we give up...

Hampton University in Virginia. A massive dust storm is also ruled out, as they normally don't reach above 60 kilometres and the blob doesn't carry Mars's dusty red signature.

OK, now we're getting really desperate. Could the explanation be biological? Whether there is life on Mars is one of the planet's major mysteries (see left), but any alien-hunters excited by the blobs should calm down, says Sánchez-Lavega: "No life past or present [has been] detected so far on Mars, so it cannot be." Heavens says there isn't really enough data to rule either way, but it's better to be cautious. "If there is no positive evidence, you should probably exclude something biological."

What to do? Just wait and hope the object turns up again,

although Peach thinks that the favourable conditions of 2012 may not reoccur for some time. "The season on Mars is very cloudy around that time of year, and that just happened to occur at opposition" – when Mars and Earth are aligned on the same side of the sun. That particular close combination won't happen again for over a decade.

Perhaps one of our robot minions will be lucky. MAVEN's orbit would have allowed it to fly through the blob, but the probe only reached Mars last year. "MAVEN should see something like this very easily if it occurred again, if we were at the right place at the right time," says Jakosky. "I've given a heads-up to our science team, so they'll be keeping an eye out for it." ■

Cancer's path depends on mutation order

IT IS well known that cancers can develop from mutations in DNA – but now we've seen for the first time that a person's fate may depend on the order in which they occur.

In every cancer, there are hundreds of mutations, but some have more of an effect on the disease than others. It has now been shown that a cancer's path changes depending on which of these "driver mutations" comes first. This affects how the cancer develops, and which treatments are likely to work best.

This finding comes from an analysis of blood samples from 246 people with blood disorders called myeloproliferative neoplasms, which develop into leukaemia in about 5 to 10 per cent of cases. Researchers had access to samples from both early and later stages of the disease, enabling them to see the order in which key mutations appeared in affected blood cells.

"It's the first time we've been able to show that the order impacts both the clinical and biological features of the disease," says David Kent of the Cambridge Institute for Medical Research in the UK, and a lead author of the study (*The New England Journal of Medicine*, doi.org/z9f). "Before, we didn't know that order mattered."

Kent and his colleagues focused on mutations in two genes already known to be critical for development of this type of pre-leukaemia. A mutated *JAK2* gene sends production of red blood cells and platelets into overdrive. *TET2* normally helps kill abnormal stem cells, but when it mutates, unhealthy cells slowly build up in the bone marrow.

A tenth of the initial 246 blood samples had both mutations. Of these, the team identified 12 samples in which *TET2* had unequivocally mutated first, and another 12 in which the *JAK2* mutation came first.

By taking further samples from these people and tracking their symptoms, they were able to show

that the disease took a different trajectory depending on which mutation came first.

They found that disease was noticeable 10 years earlier in people with *JAK2*-first mutations, because they were overproducing blood cells at high levels from the outset. In cell culture, these mutants were easier to kill with targeted *JAK2* inhibitor drugs than cells from those with *TET2*-first mutations, but Kent's team has yet to test that this is also true inside the human body.

By contrast, the disease was more hidden in those who developed *TET2* mutations first and was more likely to develop into full-blown leukaemia, but people in this group were less

"It's the first time we've shown that order impacts the clinical and biological features of the disease"

likely to suffer or die from blood clots than those who developed *JAK2* mutations first. "It's not a case of one being milder than the other, but that they drive disease in different directions," says Kent.

"This is a landmark study," says Charles Swanton of Cancer Research UK's London Research Institute. "It's the first to conclusively demonstrate that the order in which two driver events occur influences the subsequent evolution of the tumour, the underlying biological behaviour, type of disorder and clinical presentation of the disease," he says.

If the effects of mutation order were established for all common cancers, it could have a dramatic impact on treatment, says Kent. Doing this is likely to be easiest for cancers for which regular early biopsies are taken, such as breast and prostate cancer.

"We hope that our study will stimulate the search in other cancers for whether or not the order of mutation acquisition matters," he says. Andy Coghlan ■

Map tells us how life nudges genes

Catherine Brahic

THE nature versus nurture debate is getting a facelift this week, with the publication of a genetic map that promises to tell us which bits of us are set in stone by our DNA, and which bits we can affect by how we live our lives.

The new “epigenomic” map doesn’t just look at genes, but also the instructions that govern them. Compiled by a consortium of biologists and computer scientists, this information will allow doctors to pinpoint precisely which cells in the

“Epigenomic medicine won’t extend your life, but make the years spent in physical decline a whole lot better”

body are responsible for various diseases. It might also reveal how to adjust your lifestyle to counter a genetic predisposition to a particular disease.

“The epigenome is the additional information our cells have on top of genetic information,” says lead researcher Manolis Kellis of the Massachusetts Institute of Technology. It is made of chemical tags that are attached to DNA and its packaging. These tags act like genetic controllers, influencing whether a gene is switched on or off, and play an instrumental role in shaping our bodies and disease.

Researchers are still figuring out exactly how and when epigenetic tags are added to our DNA, but the process appears to depend on environmental cues. We inherit some tags from our parents, but what a mother eats during pregnancy, for instance, might also change her baby’s epigenome. Others tags relate to the environment we are exposed to as children and adults. “The

epigenome sits in a very special place between nature and nurture,” says Kellis.

Each cell type in our body has a different epigenome – in fact, the DNA tags are the reason why our cells come in such different shapes and sizes despite having exactly the same DNA. So for its map, the Roadmap Epigenomics Consortium collected thousands of cells from different adult and embryonic tissues, and meticulously analysed all the tags.

So far, they have produced 127 epigenomes, each corresponding to a different cell type, from brain cells to skin cells. That’s a big advance on the 16 published in 2012 by the ENCODE project, which are included in the new map.

The consortium also cross-referenced these healthy epigenomes with previous data on the genetic components of dozens of diseases, including type 1 diabetes, Crohn’s disease, high blood pressure, inflammatory bowel disease and Alzheimer’s disease (see below).

The results, says Kellis, allow doctors to see what cell types are



Limber up: tweak that epigenome

likely to be disrupted in people with these conditions. For instance, they suggest disruptions in the epigenome of the brain’s cingulate gyrus cells may play a role in attention deficit hyperactivity disorder (*Nature*, DOI: 10.1038/nature14248).

Richard Meehan of the

University of Edinburgh, UK, says the work offers “incredibly valuable information which will be absorbed and debated for years to come”. He suggests that one day doctors will look at your epigenomes during routine health checks to suss out how the nature versus nurture battle is playing out inside your cells. These scans would reveal your genetic predisposition to certain conditions, and how your lifestyle is affecting those risks.

By adjusting your choices accordingly, you will be able to delay disease, or minimise its effects for as long as possible. “It’s not going to move any further forward the point at which your life ends, but make the years up to that point – years that are spent in physical decline – a whole lot better,” says Meehan.

“You see this on *Star Trek*,” he adds. “Nobody lives any longer but they just seem to be healthier up to the point where life, unfortunately, passes away.” ■

ALZHEIMER’S EPIGENETICS

While you can’t change the genes you were born with, you might be able to alter your epigenome – and its influence on your health – through tinkering with your lifestyle.

Studying cells from people with Alzheimer’s and a mouse version of the disease highlights both immune cells and brain cells as key players. This finding supports other studies suggesting that an immune disorder is at least partially responsible for Alzheimer’s.

Manolis Kellis and his team at MIT (see main story) were able to identify both genetic and non-

genetic effects. While the immune disruptions were coded in the cells’ genetics, the changes in the brain cells appeared to be influenced by environmental inputs like diet, education, physical activity and age, and are probably associated with epigenetic changes (*Nature*, DOI: 10.1038/nature14252).

“We have an interplay between genetics and epigenetics,” says Kellis. “You might not be able to do anything about the genetic but you might be able to do something about the epigenomic by – I don’t know – maybe reading more books.”

I'm hungry and I want to go shopping - now

SHOPPING on an empty stomach? Go eat something quick! People buy more stuff and spend more money when they are hungry - and not just on food.

Hunger is known to increase food purchases, but Alison Jing Xu at the University of Minnesota and her team wanted to know if it also increased desire to buy non-food items. So they asked 63 people to come to the lab with an empty stomach. Half were given a piece of cake to eat before all the volunteers were asked to examine a binder clip and decide how many they would like. They were also asked how much they liked the clips and how hungry they were on a scale from 1 to 10. Hunger had no effect on how much people liked the clips. However, hungry participants - who had an average hunger score of 7.72 - asked for 70 per cent more free clips than those who had just eaten.

To find out if the same association held true for real purchases, the team asked 81 customers leaving a large department store that sold mostly non-food goods whether they could have a peek at their receipt. They also asked them to rate their hunger and their mood. Customers with hunger scores above the median score for the whole group spent 64 per cent more than those who were less hungry, even when the team allowed for mood and time spent shopping (PNAS, DOI: 10.1073/pnas.1417712112).

So what's going on? When we are hungry, our stomach releases a hormone called ghrelin. This acts on an area of the brain called the ventromedial prefrontal cortex, which is involved in reward and motivation, making people want to seek out and consume calories.

Jing Xu suggests that ghrelin's effect isn't restricted to food. "We'd like to make consumers aware of the possibility that if they go shopping on an empty stomach, they might spend more money than they intend to - so better to feed themselves before they go out," she says. Helen Thomson ■



AP PHOTO/CHELYABINSK, RU. YEKATERINA PUSTYNNIKOVA

Down in flames

How low can they go? Meteors, that is

GREAT balls of fire rip through Earth's atmosphere every day - but guessing which will hit the ground has been a challenge. Now, a model predicts how high up each incoming space rock will be when it bursts into flame - and whether people on the ground should look out for shrapnel.

When space rocks are unlucky enough to cross paths with our planet, friction in the atmosphere bakes them up and turns them into fireballs. Most of the time, this happens high enough that they don't pose a threat, burning up totally before nearing the ground. "Our atmosphere provides an effective shield against these otherwise dangerous projectiles," says Manuel Moreno-Ibáñez of the Autonomous University of Barcelona in Spain.

But the low-fliers can do some damage, whether or not they reach the surface. Two years ago, for instance, a meteor exploded 29 kilometres over the Russian region of Chelyabinsk, outshining the sun and releasing more

energy than 20 atomic bombs. Bigger, lower rocks have famously been blamed for mass extinctions.

So scientists would like a way to predict what happens to rocks of different shapes, sizes and rotations as they approach us. Now, Moreno-Ibáñez and his colleagues have figured out how to precisely calculate a

"Recovering meteorites from fireball events teaches us about objects that could threaten Earth"

rock's flame-out height using two parameters: how much aerodynamic drag it feels, and how the atmosphere heats it up.

After finding these magic numbers using rocks' trajectories, they modified an existing equation to better reflect reality, allowing them to calculate how deep the rocks are likely to penetrate into our atmosphere.

The team then tested the model on past fireballs, whose trajectories and heights were known from the Meteorite

Observation and Recovery Project, an observation campaign that ran from 1971 to 1985 using 60 sky-scanning cameras in Canada. The method worked, mirroring what the cameras saw (*Icarus*, doi.org/z82).

Next, the team plans to test the model further by running the numbers on the Chelyabinsk meteor and others. Ultimately, they hope to calculate the heights of future fireballs and the landing sites of any fragments.

Unfortunately, this method won't work for dinosaur-killers, which are big enough to remain intact when they heat up. But the smaller rocks that reach Earth as meteorites can teach us about their larger cousins. And the model is useful for finding those: it predicts the energy fragments will have if and when they hit, and where that will be.

"Recovering meteorites from fireball events provides us with an opportunity to learn more about the solar system and, more importantly, the materials that comprise objects in space that could potentially threaten Earth," says Michael Hankey of the American Meteor Society. "Every meteorite that lands on Earth is a piece of space."

Although these bursts happen frequently, cameras must scan the right part of the sky at the right time to see them. NASA and other space agencies have a number of ground and space-based telescopes scanning the skies for dangerous rocks, and the private B612 Foundation wants to launch a space telescope called Sentinel dedicated to the task.

Still, there could be more bad news out there. Chelyabinsk, for example, caught us off-guard, and so far only a few meteorites have been tracked from space to the ground. The model offers some hope that future research will be more fruitful, but also highlights the need for vigilant telescopes. After all, we can only predict the fallout from big space rocks if we see them coming. Sarah Scoles ■

Campaigners split on proposed ban

Clare Wilson

WOULD it champion gender equality, or undermine a woman's right to choose? A ban on abortions based on the sex of the fetus will be considered by the UK parliament next week.

Supporters of a ban say that women from some ethnic minorities occasionally abort female fetuses and try instead for a son. Yet others say any such ban cannot be enforced and could damage hard-won abortion rights enshrined in UK law since 1967. "Gender selection is a horrible concept and it's easy to have a knee-jerk reaction," says Tracey Masters of the Royal College of Obstetricians and Gynaecologists. "But this [ban] would interfere with clinical care."

Sex-based abortions are a grey area of UK law. After a newspaper covertly filmed three doctors agreeing to arrange one, the health secretary stated that such abortions are illegal. But the doctors were not prosecuted because, according to legal advice, abortion in these circumstances is not necessarily unlawful.

It's hard to know how many terminations based on gender are

taking place. About 98 per cent of UK abortions are on the grounds of risk to mental health – in effect, saying that having the baby would cause stress and anxiety. Some might argue that having an unwanted girl would fit into this category too, although the number of abortions carried out for this specific reason is not recorded.

Sex ratios give some insight. In some parts of China and India these are severely skewed in favour of boys.

There is no such distortion for the UK as a whole, but one study that broke down births by ethnic group suggests that Indian-born mothers are more likely than usual to have a boy if they already have two or more girls, with the ratio for children born third or later reaching 115 boys for every 100 girls. This could be the result of gender-based abortions.

If so, it is happening because women are pressured by their families, says Jasvinder Sanghera of Karma Nirvana, a charity that campaigns against forced marriage. Some hospitals in areas with high South Asian populations won't reveal the baby's sex at the 20-week scan for this reason, she says.

And gender-based abortions could become more common with the recent arrival of sex tests that can be done at two months, using fetal DNA in the mother's blood. At this early stage drugs can be used to abort the pregnancy, avoiding surgery.

But changing the law would set a harmful precedent, according to Genetic Alliance UK and Antenatal Results & Choices, both of which advise families with serious inherited conditions. "For the first time it would set on statute that doctors must prioritise a characteristic of the fetus over the well-being of the woman," the two groups said in a statement to members of parliament last week. Some parents opt for sex-based abortions to reduce the risk their next child will be affected by an inherited condition.

Ultimately, though, any new law would be impossible to police because women having an abortion could simply lie about their motives. Sanghera argues that it would nevertheless send out a message about the equal value of girls.

But Masters says that doesn't justify endangering women's access to abortion. "If you start to give reasons that are not OK, it implies that only some reasons are OK," she says. "We must allow a woman and her doctor to make the decision without judgement from others. Our bottom line is that we have to trust our patients." ■



Boy or girl?

Discovered: two new mammals from dino era

IN THE days of the Jurassic, dinosaurs ruled Earth, while mammals cowered in the shadows. At least, that used to be the idea. Two remarkably preserved fossils from China are changing that, revealing a surprising diversity among early mammals.

The two specimens lived 165 to 160 million years ago, and the lifestyles they were adapted for show

that they evolved similarly to modern mammals, and weren't severely constrained by the presence of the dinosaurs, says Zhe-Xi Luo of the University of Chicago.

This puts paid to the long-standing view, based on tiny teeth and some jaw fragments, that early mammals were primitive, shrew-like insectivores. The idea was first challenged about 10 years ago with the discovery of more complete skeletons, including a honey-badger-sized predator of baby dinosaurs, and a beaver-like fish-eater called *Castorocauda*.

Now Luo and his colleagues have found two small but highly specialised relatives of *Castorocauda*. *Docofossor* is the earliest digging mammal ever discovered (*Science*, doi.org/z9p). Like the modern African golden mole, it had shovel-like fingers that were strengthened by losing a bone segment. *Agilodocodon scansorius* is both the earliest tree-dwelling mammal identified and the first to eat

"We would think of these animals as furry mammals, but we might notice they had funny heads"

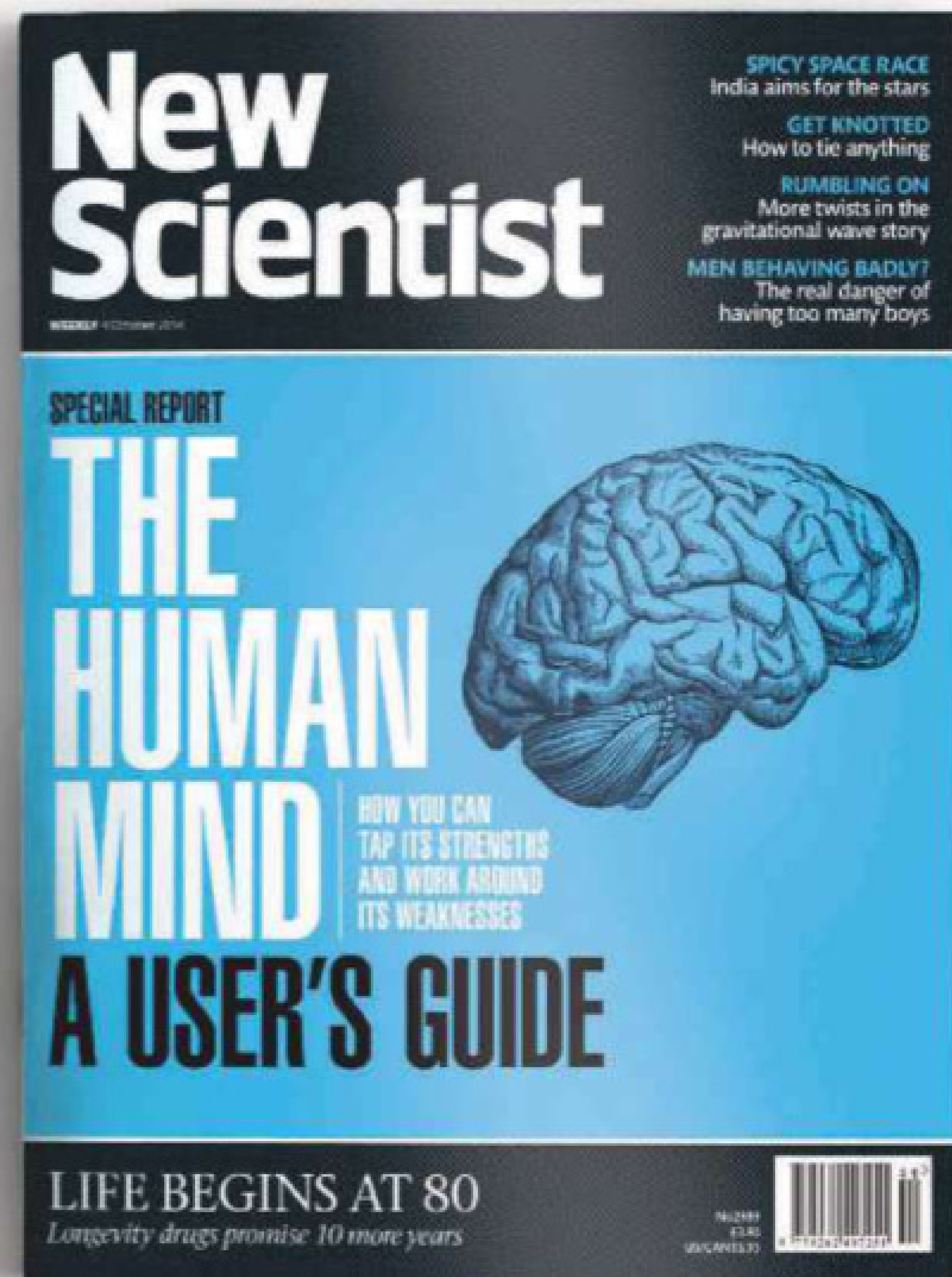
plants (*Science*, doi.org/z9q). It had curved claws, a bit like those of some squirrels, and spade-shaped teeth that would have enabled it to gnaw into bark to feed on tree gums or saps.

These species were part of a group that has no living descendants, called docodonts, which was outside what we consider to be true mammals. "If we could go back to the Jurassic, we probably would think of these animals as furry mammals, but we might notice that they had funny heads or moved awkwardly," says Anne Weil of Oklahoma State University in Stillwater. Jeff Hecht ■

Morning pick me up



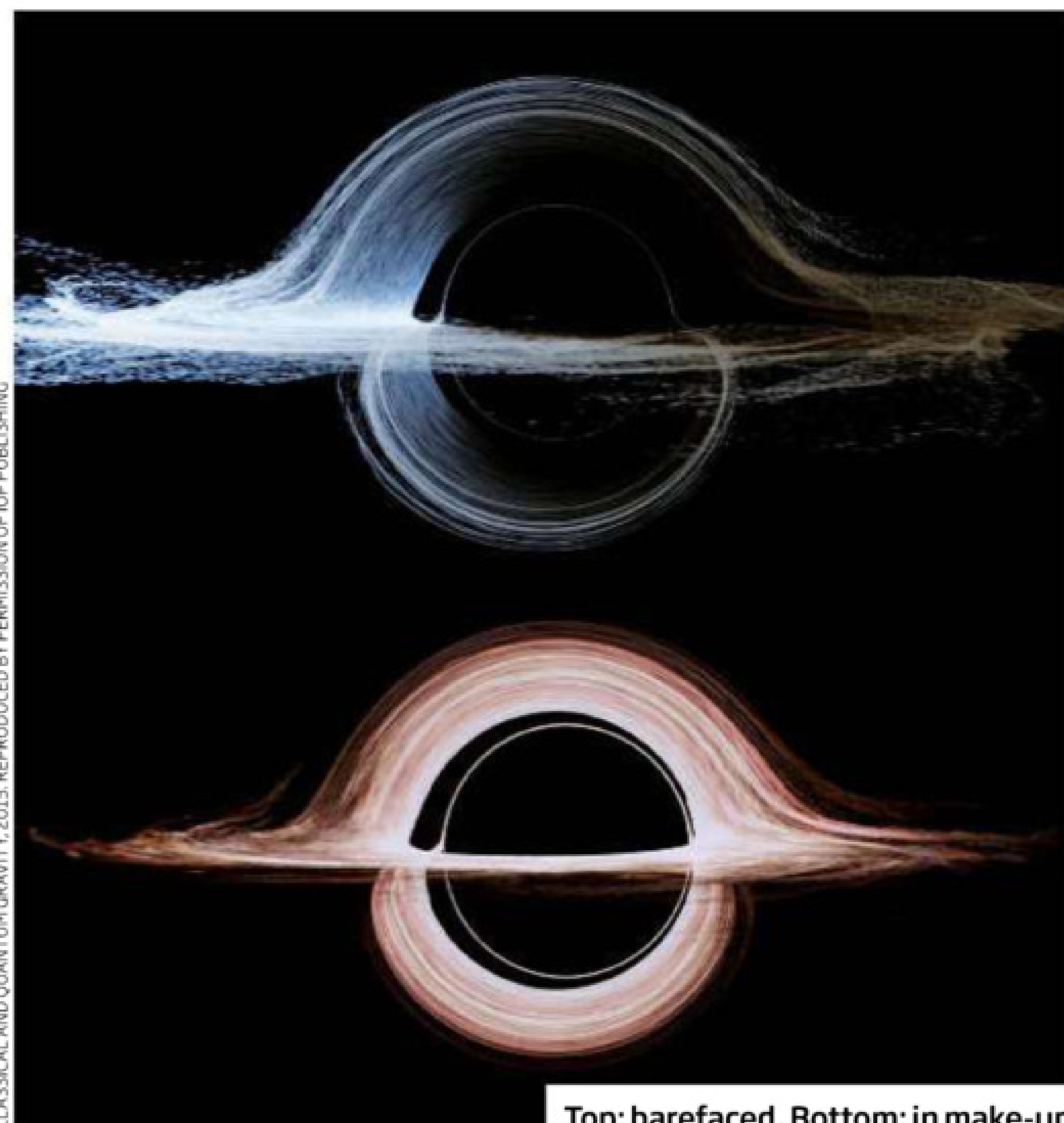
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Top: barefaced, Bottom: in make-up

Black hole all dolled up for *Interstellar*

Jacob Aron

EVEN black holes wear make-up in Hollywood. Last year's hit film *Interstellar* used scientific equations to depict what happens when spacefarers venture near a supermassive black hole. Now, a joint paper in the journal *Classical and Quantum Gravity* from the movie's visual effects team and scientific consultant reveals that the real black hole was deemed too confusing for audiences, and some of the science had to be toned down.

Interstellar's premise was conceived by physicist Kip Thorne of the California Institute of Technology, who wanted to make a realistic movie about black holes. He got together with director and co-writer Christopher Nolan, along with London-based visual effects studio Double Negative, to create the movie's black hole, Gargantua.

"I'd ask him a question and maybe a week later, sometimes a month, I'd get a beautifully

squashed up against one side. That's because the black hole had to spin very fast to cause the movie's time dilation effects, dragging the light to one side. Nolan didn't like this asymmetry and thought moviegoers wouldn't understand, so the team slowed the black hole down, says James.

Gargantua's disc in the movie is also redder and brighter than it would be in reality. The black hole's rotation turned the glowing red matter a cool blue, thanks to the Doppler effect shortening the wavelength of the light it gave off. It also made one side of the disc much darker, to the point of almost being invisible. Again, Nolan vetoed these details.

"The first images we gave him didn't have the Doppler shift, and I think he fell in love with them," says James.

"When I saw the movie, I immediately saw that the black hole did not look as it should," says Andrew Hamilton of the University of Colorado in Boulder. But after reading the paper, he's glad to see they slowed it down for a reason. "I had not realised just how careful the *Interstellar* team had been with their renderings."

Alain Riazuelo of the Paris Institute of Astrophysics says a pure science project would have done things differently, because astronomers want to create models of what their telescopes might see from afar. "From an astrophysics perspective you would want to simulate different configurations of matter around the black hole, then try to predict what your observations would give you," he says – the team just chose a disc they thought looked nice. "You should keep in mind there was nothing that obliged Christopher Nolan to try to stick to realistic science." ■

"The first images we gave him didn't have the Doppler shift, and I think he fell in love with them"

presented paper that he'd laid out with references going into the history of the problems I'd been asking about," says Oliver James, chief scientist at Double Negative.

Gargantua's most striking element is its accretion disc, the glowing ring of matter that encircles it. The team started out using a simple, rainbow-coloured flat disc to figure out how it would be warped by the black hole, then exchanged it for a more wispy disc with realistic colours.

The result looked good, but the central black hole seemed to be

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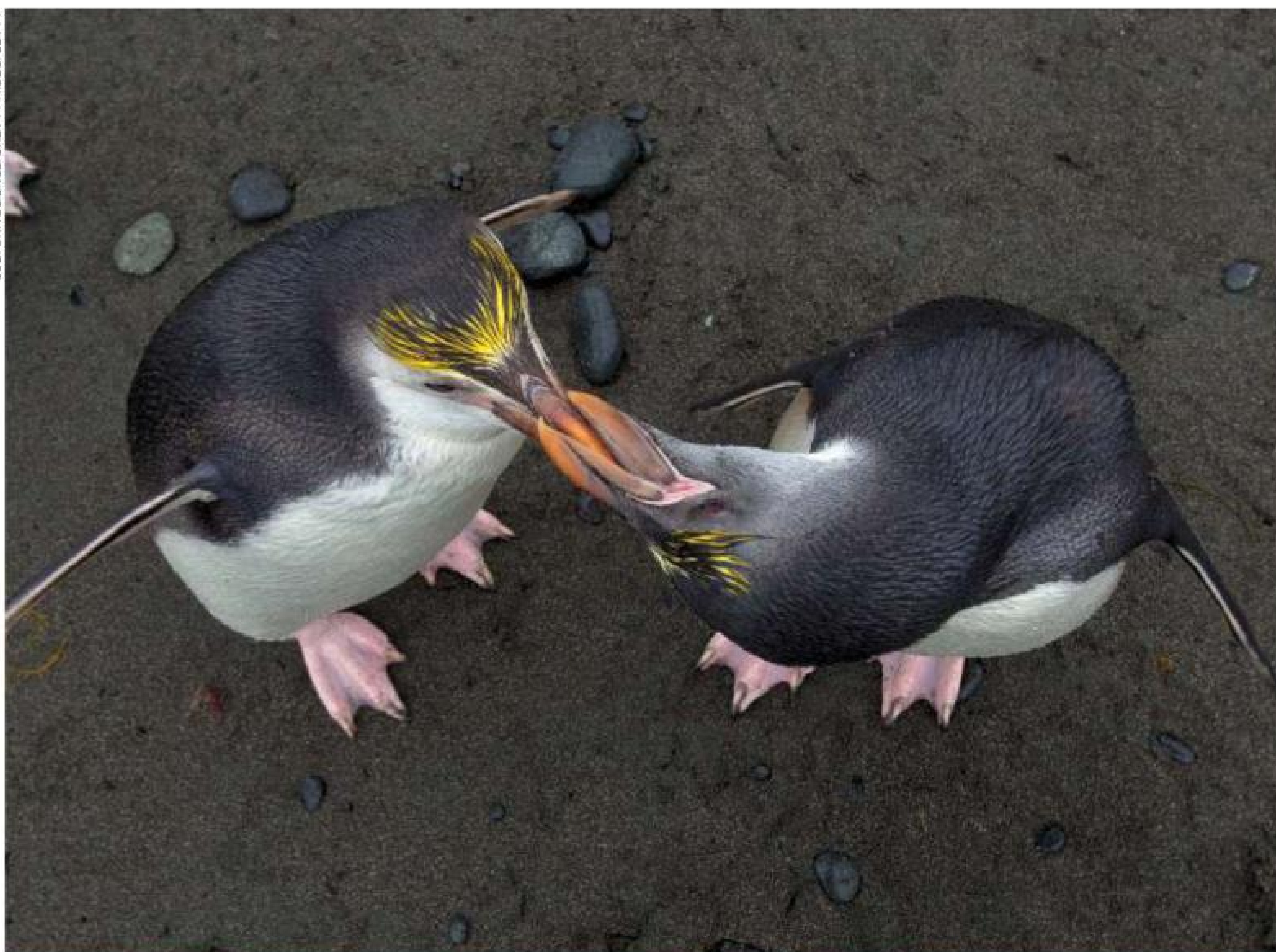
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No need to taste the fish if you swallow it whole

PITY poor penguins' paltry palates. All they can taste, it seems, is saltiness or sourness. Lost is their ability to savour the sweet, bitter or umami flavours enjoyed by most animals. The receptors for these tastes may simply not work at the chilly temperatures in their habitat.

Researchers discovered the birds' taste deficits after screening their DNA for genes associated with taste buds. They drew a blank when looking for those that code for proteins usually used in detecting sweet, bitter and umami tastes (*Current Biology*, DOI: 10.1016/j.cub.2015.01.026).

"As far as we know, penguins are the only birds that have lost three of the five basic tastes," says Jianzhi George Zhang of the University of Michigan in Ann Arbor, who led the study.

The key, he believes, is the absence of the gene that makes TRPM5, a protein vital for the three lost taste types, but not the surviving two. Previous studies showed that TRPM5 doesn't function at low temperature, so the cold Antarctic may have made the three tastes unusable. Another possibility is that they became redundant because penguins often swallow their prey whole, so have little need for them. The two remaining tastes may allow them to avoid rotten food and keep track of their salt intake. "It's likely that having sour and salty tastes is still beneficial to penguins," Zhang says.

Common mouth bug helps colon cancer

WHAT do your mouth and your behind have in common? The answer may be a cancer-enhancing bacterium.

Fusobacterium nucleatum can cause gum disease, but until recently it was assumed to be just one of many relatively harmless bacteria that live on our bodies.

But the bacterium may have a darker side. It has recently been identified in high numbers in

human colorectal tumours. Now researchers have shown that it seems to enhance colon cancer, by inhibiting the cancer-killing ability of natural killer cells, the first line of our immune defence against infection and cancer.

Gilad Bachrach at the Hebrew University-Hadassah School of Dental Medicine in Jerusalem and his colleagues found that a bacterial protein called Fap2 binds

to a receptor on the surface of natural killer cells, helping tumour cells evade the immune system (*Immunity*, doi.org/z8r).

"By activating this receptor, *F. nucleatum* prevents the killing of cancer cells by the natural killer cells," Bachrach says.

The bacterium-tumour relationship is probably mutually beneficial. *F. nucleatum* likes to grow in low-oxygen conditions, and tumours often provide such environments.

Kill desk bugs with sticky tape

WANT to keep bacteria at bay? Reach into your desk drawer. A roll of transparent adhesive tape can be turned into a nifty antibacterial sheet.

Depositing metal nanoparticles on a film's surface can give it remarkable properties: silver turns it antibacterial and copper anti-fungal, with gold making it conduct electricity. The tricky bit is getting the film to accept nanoparticles: a harsh chemical bath is the usual way to break its surface bonds.

But sticky tape comes ready for the job. Just unpeeling it breaks chemical bonds in the adhesive, priming it to react with metals, say Bartosz Grzybowski of Northwestern University in Evanston, Illinois, and his colleagues (*Journal of the American Chemical Society*, doi.org/zzn). To coat the tape, unpeel, soak it in a solution of metal salts, and you're done.

Orion sports a giant dust hula hoop

A BAND of stars may have blown enormous smoke rings in Orion.

Eddie Schlafly of the Max Planck Institute for Astronomy in Heidelberg, Germany, and his colleagues observed the Orion nebula complex, a huge star-forming region that has its centre in the constellation. They analysed some 23 million stars to create a 3D map, and found a dust ring about 330 light years wide (*Astrophysical Journal*, doi.org/z8t).

The team thinks that massive stars, which spew enormous amounts of energy, carved a bubble in the region's gas and dust, pushing dust to the bubble's edge to form a ring. These stars have since burned out, but finding their lower mass siblings could confirm the idea.

Leaf insects want male-free life

WHO needs men? Female spiny leaf stick insects have figured out how to reproduce without males, and fight off any suitors ferociously.

The leaf insect *Extatosoma tiaratum* is facultatively parthenogenetic, which means females can shift between sexual and asexual reproduction. If a female hasn't mated before laying eggs, only clones of the female are hatched. Parthenogenesis is rare in the animal world, and is thought to have evolved during times when low population densities resulted in a scarcity of males.

If this were true in *E. tiaratum*, females would be trying their best to find a mate. Instead, they are so into their all-female lifestyle, they have evolved an anti-aphrodisiac to keep the males away. If that doesn't work, they have a few self-defence moves that make it tough for the male to hold on during mating: curving their abdomen and kicking with their hindlegs (*Animal Behaviour*, doi.org/z2z).

"It's probably unlikely that parthenogenesis evolved in this species as an adaptation to mate scarcity or low density," says Nathan Burke at the University of New South Wales in Australia. It may be that costs associated with sex, such as attracting and finding mates, are just not worth the hassle for the females of this species.



Jostling photons could give dark matter away

DARK matter may not be so dark after all. If the invisible stuff interacts with light, it could glow bright enough to be seen.

Dark matter is thought to make up 85 per cent of the universe's mass, but interacts with regular matter through gravity alone. That means light doesn't radiate from it or reflect off it. But direct searches for dark matter have come up empty, leading some physicists to suspect the theories aren't right.

So Jonathan Davis and Joseph Silk at the Astrophysical Institute

of Paris, France, asked what would happen if light could interact with dark matter. They calculated the interaction rate needed between photons and dark matter to produce an observable glow.

They found that even if photons collide with dark matter particles a hundred to a million times less often than they would with normal matter, their interaction would still make a spiral galaxy's outskirts – where there is more dark matter than regular matter – appear brighter than they would otherwise

(*Physical Review Letters*, doi.org/z8s). This would produce a glow at the periphery, where it is easier to observe and doesn't have to compete with light from the galaxy's stars, says Davis. This effect might be stronger in lower-energy light, like infrared instead of ultraviolet.

"It's a clever idea," says Michael Boylan-Kolchin, an astronomer at the University of Maryland. "Since we haven't yet detected dark matter directly, it's important to constrain its properties in as many ways as possible."

Dieting's benefits, minus the starving

DIETING or hitting the treadmill no fun? You might be able to enjoy one of their lesser-known health benefits without the hassle.

Exercising hard or not eating for a while can alter the immune system's behaviour, suppressing some types of inflammatory response. That, in turn, seems to protect against Alzheimer's disease, diabetes and autoimmune conditions. But what triggers the change in the immune response has been unclear.

When starved of glucose, its usual energy source, the body can use chemicals called ketones instead. To find out if one of these suppresses inflammation, Vishwa Deep Dixit from the Yale School of Medicine doused human immune cells with various ketones. When he upped the dose of a ketone called BHB to the level seen after two days of fasting, the inflammatory response fell away.

Injecting BHB into mice genetically engineered to have autoimmune disease reduced their symptoms compared with control mice (*Nature Medicine*, 10.1038/nm.3804). Dixit says this takes us a step closer to devising a pill that offers some of the benefits of dieting and exercise.



US faces 40-year mega-droughts

HELL on Earth? Droughts lasting for decades could make the Dust Bowl of the 1930s look like a picnic. And they could hit south-western and central regions of the US in 50 years' time, thanks to climate change drying the soils through evaporation.

The impact on agriculture would be huge, possibly triggering "water wars" as farmers fight over resources that become ever more scarce.

"Instead of lasting maybe 10 years, these mega-droughts will last 20, 30, maybe even 40 years," says Benjamin Cook at the NASA Goddard Institute for Space Studies

in New York, who led the study.

Cook and his colleagues made their predictions after analysing drought conditions in the US over the past 2000 years, based on tens of thousands of tree-ring samples collected throughout the country (*Science Advances*, DOI: 10.1126/sciadv.1400082). The droughts could be worse than anything seen in the past millennium, even with moderate action to reduce emissions. "The question is, to what extent will current strategies work with the much more serious droughts that are outside our experience?" asks Cook.



Whistleblower, or just a snitch?

Dark secrets for sale

A new site that lets people sell secret documents online will make life easier for whistleblowers – and blackmailers, says **Chris Baraniuk**

PSST, wanna know a secret? You'll just have to give me some money first. That's how the creators of Darkleaks, a "black market where you can sell information", imagine the next generation of whistleblowers will operate.

The impact of whistleblowers today has never been greater: from Edward Snowden's revelations about mass surveillance to the HSBC employee who exposed the bank's efforts to help clients evade hundreds of millions of dollars in tax payments.

But not all leaks are in the public interest. For example there has also been a sharp rise in malicious leaks, such as the 500 private photographs of

celebrities which were distributed online last August.

Darkleaks could facilitate all kinds of disclosure, positive and negative, via an anonymous marketplace. The service is available to download online as a free software package and its source code has been published openly online via code-sharing website Github. Users can upload a file with a description that can be viewed by potential buyers browsing the marketplace. This is all done within the software itself.

Its developers say that individuals may wish to use the service to anonymously auction off "trade secrets", "military intelligence" and "proof of tax

evasion" among other, rather more unsavoury, things.

Darkleaks promises to make transactions for this sort of material anonymous. A blog post announcing the tool insists: "There is no identity, no central operator and no interaction

"The US's punitive attitude to whistleblowers could force them into using exchanges like this"

between leaker and buyers."

Instead, the documents are broken into smaller chunks, encrypted by Darkleaks and added to the bitcoin block chain, a register of bitcoin payments. This

is possible because minuscule bitcoin transactions can be used by anyone to store data in the block chain. Indeed, there are already services like Storj which offer to store data in bitcoin-style block chains in this manner.

Crucially, small pieces of a file up for sale will be released to potential buyers so that they can verify its contents before committing to a transaction for the whole thing. When they have made that commitment, and the seller claims his or her bitcoins, a key will be released allowing the buyer to decrypt the document in question.

It's just one of a series of "platforms" for leaking sensitive information which have appeared in recent years. From WikiLeaks to the *Guardian* newspaper's SecureDrop software, there are now many technological portals to which leakers may turn in an effort to get a burning secret out. And projects such as GlobaLeaks hope

to create a decentralised forum for the release of information.

However, until now none of these services has featured direct payment for a leak.

So is the financial aspect really necessary? Annie Machon, a former MI5 intelligence officer and whistleblower, says it is unfortunate that Darkleaks has equated whistleblowing with selling information. This is also the opinion of Beatrice Edwards, executive director of the Government Accountability Project in the US.

"When you're selling information you're not really a whistleblower under the legislative legal definition in almost any country," she points out. Only in special circumstances, such as the US financial services, when whistleblowers may receive a cut of fines imposed on their corporations, has this been enshrined in law. However, Edwards adds that the current climate may encourage whistleblowers to take unusual steps in order to protect themselves and release information in the public interest.

Going underground

"We have seen in the US an increasingly punitive attitude on the part of the government towards whistleblowers," Edwards says. "This could force them into some underground exchange of information like this because the Obama administration prosecutes national security whistleblowers rather than protecting them."

Machon agrees. "You do need these sorts of groups," she says. "We are looking at a period of small, nimble information freedom fighters pushing back against these homogenised corporate and state powers to protect our basic human rights."

James Young is an attorney at international law firm Morgan & Morgan who represents whistleblowers in the financial industry. He says that those wanting to expose wrongdoing

have expressed a need for more secure channels through which to do so.

"There is a need for whistleblowers to confidentially and securely share information with news media, attorneys, the government or whoever might be the right person to get it," he says. "With everything we know about cellphones and the internet, there's no sure-fire way to do that right now."

Some may question the darker side of Darkleaks. One of the suggested disclosures that users could make via the service, according to its creators, is the publication of "celebrity sex pictures". Already, one individual claims to be auctioning thousands of passwords and private messages via the site, though this has not yet been verified.

For Edwards, this is where the definition of whistleblower breaks down. "In distinction from a whistleblower, a snitch or an informer pursues his or her own interest. Someone who is selling information and needs to anonymise the exchange is probably someone who fits in to that category," she says.

Cody Wilson is an anarchist and co-founder of Dark Wallet, a digital bitcoin wallet which promises to make transactions practically impossible to trace. Wilson was not involved in the development of Darkleaks but says he has watched the service's launch with interest. "It's a necessary step for the advancement of decentralised and block chain-based technologies," he says, arguing that corporations and state dominance should be challenged more aggressively by the public.

Wilson achieved notoriety in 2012 when he launched the Wiki Weapon Project, which allowed anyone to download 3D printable guns via the internet. Will people suffer as a result of unsavoury leaks made via Darkleaks? "Without a doubt," he says. "There are going to be victims." ■

Lasers set to stun engines into efficiency

PEW pew! For a week last November an internal combustion engine hummed away in a lab near Chicago. Why the excitement? This particular engine sets fire to fuel with lasers instead of spark plugs, burning fuel more efficiently than normal. Laser-fired engines could lead to cleaner, greener cars.

In a normal combustion engine, a mix of fuel and air enters a chamber where it is ignited by a spark plug. Hot, expanding gases from the burning fuel then exert force on a moving part such as a piston - generating mechanical energy that can be used to turn the wheels of a car, for example. But because each combustion cycle happens very quickly, it is hard to get all of the fuel mixture to burn. The problem is that spark plugs can only ignite the fuel at one end of the chamber, says Chuni Ghosh, CEO of New Jersey-based Princeton Optronics, the firm that developed the new ignition system.

In Ghosh's engine, a laser ignites the fuel in the middle of the chamber instead, burning more of the fuel and improving combustion efficiency by 27 per cent. Laser ignition could boost the fuel efficiency of a car from 40 kilometres per litre up to around 50, for example. The more complete burn also emits fewer polluting by-products such as nitrogen dioxide.

Lasers are also better at keeping up with the thousands of cycles a minute at which a car engine runs. They can be tuned more precisely than spark plugs so that they fire at the optimal instant for ignition. They can even be fired multiple times during the same cycle into different parts of the cylinder to maximise fuel burn.

The engine was presented for the first time at the ARPA-e energy innovation summit last week in Washington DC. The idea itself is not new, but Princeton Optronics is the

"Lasers give a more complete burn that emits fewer pollutants like nitrogen dioxide"

first to show that it works in a real engine, with the heat and extreme forces that thousands of revolutions per minute produce. Toyota toyed with a similar system in 2011, but never tested it in these conditions.

Cars are not the only vehicles that stand to gain. Back-up generators and ships' engines could benefit too. "There is a lot of pressure on the shipping companies to reduce the pollution from their ships," says Ghosh. "One shipping company we are talking to is interested in retrofitting their existing engines with laser ignition." ■



Vital spark: room for improvement

HORIZON INTERNATIONAL IMAGES LIMITED/ALAMY

Subway betrays status

Smartcard swiping hints at your social class, finds **Aviva Rutkin**

BEIJING is an enormous city, sprawling over an area 10 times larger than Greater London. To get around China's capital, many residents rely on the metro, swiping a smartcard each time they jump on or off. Could their swiping patterns reveal their class?

At the Beijing Institute of City Planning, researchers led by urban planner Ying Long have been poring over the smartcard records of millions of riders to see what their travel patterns reveal.

They explored two separate, week-long snapshots of public transportation activity taken two years apart, each including the movements of more than 8 million riders along the city's bus and subway lines.

Earlier studies and surveys have identified impoverished residents based on multiple data streams,

but the researchers were able to pick out such residents using smartcard data alone. They found that those who often travel long distances are likelier to live in remote, less-desirable areas, while unpredictable movement patterns can be a sign that someone does not have a stable job or housing.

Armed with these insights into the movement of the city, Long hopes to help the government devise better planning and policies. The findings could help decide where to direct resources for social programmes such as affordable housing, for example.

"Chinese people do not like to tell others their income. The government does not have a very effective way to know people's social economic status," Long says. "We hope our research can contribute to these projects."

Detailed transportation data

can provide a novel way to take the once-invisible pulse of a city. Researchers at University College London have visualised patterns in London's daily movements using Oyster Card data. Long's team uses theirs to sort Chinese riders by their travel style, with nicknames like "early birds" or "tireless itinerants".

Other cities are also figuring out how they can better serve their residents. In Boston, the

"Chinese people do not like to tell others their income. The government doesn't have a way to know"

government will look at stats from ride-sharing giant Uber and other sources to help understand residents' daily commutes. Chicago has posted sensors on street lamps around the city to track foot and vehicle traffic, perhaps to one day let pedestrians know which routes are safest or most likely to be free of smog.

Metro data like that gathered from the Beijing smartcards shows the flow of the city, but it can also be misleading, says Anthony Townsend, a researcher at the Rudin Center for Transportation at New York University. You don't know if the rider stayed in the neighbourhood or if they hopped on a taxi or a bike to another location. Mobile phone data would provide a clearer sense of where people go.

In future, data could help small businesses know when to cook extra food or tell taxi drivers where to head for. "We're really just entering a period where researchers are getting access to this data and starting to understand what the applications are," Townsend says. "People are still exploring." ■



Christ the Redeemer mapped by drone

The iconic mountaintop statue in Rio de Janeiro, Brazil, has been immortalised in 3D. A company called Pix4D used a quad-rotor drone to take thousands of high-definition photographs of the statue, which were then stitched into a 3D model.

Contact lenses that zoom on demand

A new contact lens lets you revel in magnified vision. The lens, being developed at the Swiss Federal Institute of Technology in Lausanne, contains a ring of tiny mirrors that bounce incoming light around several times before it hits the retina, making objects appear 2.8 times larger. Electronic glasses allow the user to toggle between zoomed-in and normal vision.

Phone battery gives away your location

How your cellphone drains its battery can reveal where you are - all because the phone's energy consumption depends on the strength of the signal from nearby cellular towers. By matching energy use data to maps of tower locations, researchers at Stanford University figured out exactly where a cellphone was (arxiv.org/abs/1502.03182).



One big data stream

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Home, sweet plant

BATS roost in big groups in caves. Wrong! If you're a Hardwicke's woolly bat, you prefer to sleep in a more luxurious - and private - place.

Kerivoula hardwickii roosts inside tropical pitcher plants. These carnivorous plants usually attract insects, but *Nepenthes hemsleyana* lacks the scents that others have, so few bugs are lured in. Instead, it benefits from the faeces of this tiny bat, which provides more than a third of its nitrogen and may be crucial to the plant's survival.

"This is the only bat species that has ever been found roosting in pitchers," says Caroline Regina Schöner, whose team discovered the bats in 2009. "These bats managed to find a niche that no one else is occupying."

To take these images, Merlin Tuttle waded through tropical forest peat swamps on Borneo. Once he had found an occupied plant, he would spend a few hours taming a bat before snapping it from his portable studio, which provided protection from heavy rains. "It only takes a small fraction of a second for a bat to either enter or emerge, so capturing the action at just the right moment is a real challenge," says Tuttle.

Within a few days, the bats had learned to bump against his nose when they wanted him to give them some mealworms. "We were quite amazed at the intelligence of such tiny animals," Tuttle says. "Contrary to common misconceptions, bats in general are gentle, highly intelligent and trainable." Mićo Tatalović

Photographer

Merlin Tuttle Science Source

Under the whip of wellness

Urging people to optimise well-being in many aspects of life can be counterproductive, say **André Spicer** and **Carl Cederström**

FITTER, happier, more productive. If you need a wry slogan for the growing pursuit of wellness or well-being at every turn then Radiohead's lyric seems a good fit.

Few walks of life escape its influence. Medics embrace it. The UK's Office of National Statistics measures the nation's well-being. Museums justify their existence on the basis of boosting it. US undergraduates sign "wellness contracts", vowing to abstain from unhealthy lifestyles. You can even find such initiatives in prisons.

Perhaps most pervasive, though, are companies that offer corporate well-being or workplace wellness programmes, promoting goals such as weight loss, quitting smoking and stress reduction. In the US, around half of firms with 50 or more staff offer schemes.

It sounds like a good idea. But are wellness programmes as useful as they claim to be? A body



of research points to unexpected side effects and impacts that don't always match expectations. For starters, there is evidence suggesting that paying attention to your happiness, a crucial part of well-being, can actually make you less happy.

In one study, two groups watched a video that usually makes people happy – a figure skater winning a prize. Then they filled in questionnaires to assess happiness. The only difference was that before viewing the video, one group read a statement emphasising the importance of happiness and the other did not. Those who didn't read the statement were more happy after the video. Consciously focusing on our happiness can backfire.

An obsessive focus on wellness can make us more judgemental too, potentially widening societal divisions. Those who highly value

Hard to swallow

Recent criticism of US and UK dietary fat advice is flawed, says **Christine Williams**

YET again questions are being asked about the long-standing wisdom of avoiding diets rich in fat, especially saturated fats.

The latest doubts have been prompted by a study saying that randomised controlled trials (RCTs) available when dietary guidance on fat was introduced, in 1977 in the US and 1983 in the UK,

did not support the advice (*Open Heart*, doi.org/z2w). Both countries advised less fat in the diet, especially saturated fat, because of its potential to raise cholesterol, leading to coronary heart disease.

The problem is, the authors of this study have taken a classical pharmaceutical approach, assuming that RCTs provide the

gold standard for dietary study as they do in clinical trials. They don't. In fact such an approach would be inappropriate for most population-based guidance.

Most dietary guidelines have been developed using the degree of consistency in a number of lines of evidence. RCTs are part of that, but only a part. This is because results from dietary RCTs involving people with disease may not apply to the healthy population. And to do RCTs on

healthy people requires many more volunteers often studied for years. Sticking to strict diets is hard, and drop-out rates can be very high. Cost, commitment, feasibility and uncertainty about the reliability of the findings are all major challenges for such RCTs.

When the guidelines were introduced, consistent evidence for the cholesterol-raising effects of saturated fat was available via other types of research – from animal studies, comparisons of health between countries with differing diets, and observational studies of large groups over years.

In addition, there was evidence from short-term trials in metabolic

"Any suggestion that it's OK to eat more fat than currently advised remains wishful thinking"

well-being tend to view those who don't come up to their high standards as "disgusting". Moral psychology research has found that when feelings of disgust are triggered, we tend to rapidly make punitive moral judgements. For example, we are more likely to harshly judge people who "turn our stomach" and ascribe morally unattractive traits to them, such as being lazy and untrustworthy.

And while programmes in the workplace promise a lot, results can be a let-down. Some studies have found wellness initiatives only helped a small number of employees lose on average half a kilogram over a year. While any weight loss isn't to be sniffed at, are such results worth the billions spent achieving them?

It is hard to argue against a healthy diet, regular exercise, not smoking, and drinking in moderation. However, wellness can become a problem and deserves greater scrutiny when it is an unceasing command people feel they must live up to. When this happens, it can undermine the very thing it tries to promote. ■

André Spicer is a professor at Cass Business School, London, and Carl Cederström is at Stockholm University, Sweden. Their new book is *The Wellness Syndrome* (Polity)

wards, where diets of volunteers could be monitored, and in other settings with less dietary control.

While it is important that we continue to examine the evidence on diet and heart disease, this must be a holistic assessment recognising that cholesterol levels have improved over the past 30 years. Admittedly, concerns that sugars replaced saturated fats in the diet also need assessing.

But any suggestion that it is OK to eat more fat than currently advised remains wishful thinking and could harm heart health. ■

Christine Williams is professor of nutrition at the University of Reading, UK

ONE MINUTE INTERVIEW

Sun-powered adventurer

I'm flying around the planet with no fuel to show what clean power and efficient materials can do, says **Bertrand Piccard**



PROFILE

Bertrand Piccard is a psychiatrist, entrepreneur and aeronaut. He co-founded Solar Impulse to build long-range solar-powered aircraft. The round-the-world flight will begin in Abu Dhabi on 1 March and make 12 stops along the way

You flew non-stop around the world in a balloon in 1999. Did that experience inform this solar-powered flight?

The balloon flight lasted 20 days, and I worried the whole time that if we didn't have good winds – if we didn't move fast enough – we would run out of fuel. When we finally landed, we had burned 3.7 tonnes of liquid propane and only had 40 kilograms left. I promised myself that the next time I flew around the world, it would be with no fuel at all. That's how the idea for the solar flight was born.

To create the aircraft, you founded Solar Impulse with fellow pilot André Borschberg. Were you confident that you could do it?

All the specialists said it was impossible to build a plane big enough for all the solar panels and batteries we would need, yet light enough to fly. But because André and I weren't specialists, we looked for solutions outside the system. It wasn't the people selling candles who invented the light bulb, you know!

What's special about your single-seater aircraft, Solar Impulse 2?

It has a wider wingspan than a 747 jumbo jet, yet is the same weight as a family car. We have the most efficient electrical motor in the world, the best insulation, a great lighting system, the lightest construction materials. And these things can now be used in cars, homes and workplaces to create a world that uses less energy. Our goal is not just to fly a solar plane around the world. We are creating, demonstrating and promoting technologies that the planet desperately needs in order to be cleaner and more sustainable.

What factors influenced the timing and route of your flight?

It is similar to the path of the balloon flight. We chose the tropical belt so we would have long days with enough sunshine, and the March start date to avoid equatorial thunderstorms.

As you and Borschberg are flying alternate legs solo, how will you rest during flights over oceans, which will take three days or more?

I developed a self-hypnosis technique, where the body is asleep but the mind is alert to changes. This allows me to take 20-minute naps, 10 times a day, with the plane on autopilot. If it leaves a predetermined envelope of flight, an alarm and vibrations in my flight suit will wake me.

You come from a family of adventurers. What's the role of adventure in today's world?

My grandfather opened the way to modern aviation by creating a pressurised cabin. He was the first person to see the curvature of the Earth, on a balloon flight into the stratosphere. My father made the deepest dive in a bathyscaphe, for the US Navy. I grew up believing that life is interesting when you explore it, when you do things that no one has done before. The age of conquest is finished. Today, the unexplored frontiers are how to have a better quality of life on this planet, how we can end poverty, defeat disease and live sustainably.

Interview by Richard Schiffman

I'm always drawn back to the ice

The Arctic is transforming so fast it's virtually impossible for science to keep up, but **Antje Boetius** is giving it her best shot

You've spent months at a time on icebreakers in the Arctic. What's life like up there?

It's a fascinating landscape. You feel like this is an area where you don't belong – but it's beautiful. When sunlight hits the ice it glitters, and when the ship breaks the ice, the chunks flip and underneath there are sometimes fish or other animals. There are snow flowers that form on top of the ice. It almost feels like a different planet.

What are you looking for when you are there?

I'm interested in the deep sea. We have tried hard to produce high-quality images that show that the Arctic Ocean isn't a dead ocean. There's actually a lot of life on the sea floor.

I understand that there's a decent amount of biomass but not a huge amount of diversity...

Yes, and that always intrigued me. This is an ocean covered by a lid of ice at the top of the world, where it receives little light: only two, three months in the year have enough sunlight for primary production [plant and algae growth], and the rest of the year it's pitch dark. As a PhD student I took some of the first deep-sea samples of bacteria and was intrigued to find that there is quite some biomass. That told me there was an unknown source of energy for these waters.

Did you find that energy source?

I think it's the ice algae. They form big accumulations that colour the ice green and brown. There can be 100 times or even 1000 times more algae in the ice than in seawater, though of course there's less ice than there is water. But is most photosynthesis going on in the sea ice or in the water column? And when the ice is no longer there, will there be more productivity or less?

Are you talking about sea-ice loss as a result of climate change?

Yes. We were amazed by one type of algae, *Melosira arctica*. It grows in chains and forms what looks like an upside-down kelp forest, hanging from the ice. The filaments can reach 8 metres long. And because the ice drifts, they get lots of nutrients. These are the biggest accumulations of algae that we know of in the Arctic, besides kelp that grows on rocks at the shores. We have gone to great lengths to observe these algae with robots, cameras in the ice and by drilling holes. We were up there for the summer 2012 melt season, which saw record ice loss. Because of that melt, all the ice algae fell to the sea floor. The entire Eurasian basin was littered with it.

The loss of all that algae sounds like a big deal. Some scientists who have worked with ice algae say it will be the end when thick ice floes are gone because then the algae can no longer grow on the ice. I think we will lose these big forests, but there'll be floating clumps.

Presumably life on the seabed benefits if more ice algae sink down, bringing more nutrients?

Well, one weird thing is very few animals are able to eat them, so they accumulate into big masses on the seabed. In the deep sea we found only two species that ate the algae – a sea cucumber and a brittle star. In other oceans you would find millions of organisms jumping into the green patches to feed. I think this seabed abundance is brand new for the Arctic, and deep-sea life has not yet adapted to it.

What counts as the "deep sea", and are there any fish down there?

The deep sea is any part of the ocean where there is no sunlight at any point during the

PROFILE

Antje Boetius is a marine biologist at the University of Bremen, Germany, and leader of the Helmholtz-Max Planck Research Group on Deep Sea Ecology and Technology



year: where it is forever night and very cold – below freezing. It is an enigmatic environment. Russian scientists suggested there were no fish in the Arctic deep sea. We thought this for a hundred years. But a fish was discovered down there for the first time last November.

Wow! How was the fish discovered?

We have hundreds of hours of film from the Arctic sea floor, and experiments with traps, and we had never seen a fish below 800 metres. Right now there are two Norwegians sitting on a hovercraft, overwintering in the Arctic (*New Scientist*, 3 January 2015). They have a camera and occasionally they lower it to the bottom. In November, they documented a fish about 1400 metres down. It's like an eel.

Photographed for New Scientist by Achim Mulhaupt/Laif



Is it possible that this fish is a new arrival, courtesy of warming waters?

That remains to be investigated. Most likely there are simply very few deep-sea fish. I tried to get my hands on all of the data and samples ever taken in the Arctic deep sea to count the animals, but we have very little data: most of it is from German and Russian expeditions. There are less than 100 samples, and very few zoologists can name the organisms retrieved. We basically rely on one Russian lab for that.

Does that make it difficult to understand the changes that are happening now?

The environment is changing faster than we can research it. It's a shitty feeling for a scientist if you are trying to learn something

from that change and you know you're far too slow. People only started seeing that carbon dioxide in the atmosphere was increasing 30 years after it began. That is crazy. The change is happening right now and we can't wait 30 years to conclude: "Oh, by now the entire typical life of the Arctic has been lost – wow, we have finally shown it."

Is it hard to live with that feeling?

One year I do the climate change work and the next I like to do exploration work because it's just too depressing otherwise. In 2016, I have a mission to explore a gigantic underwater mountain that starts in a hole at a depth of 4000 metres and climbs 3500 metres. I'll go with robots and cameras to explore what

life we find on these very steep walls. That's not as sad as climate change research.

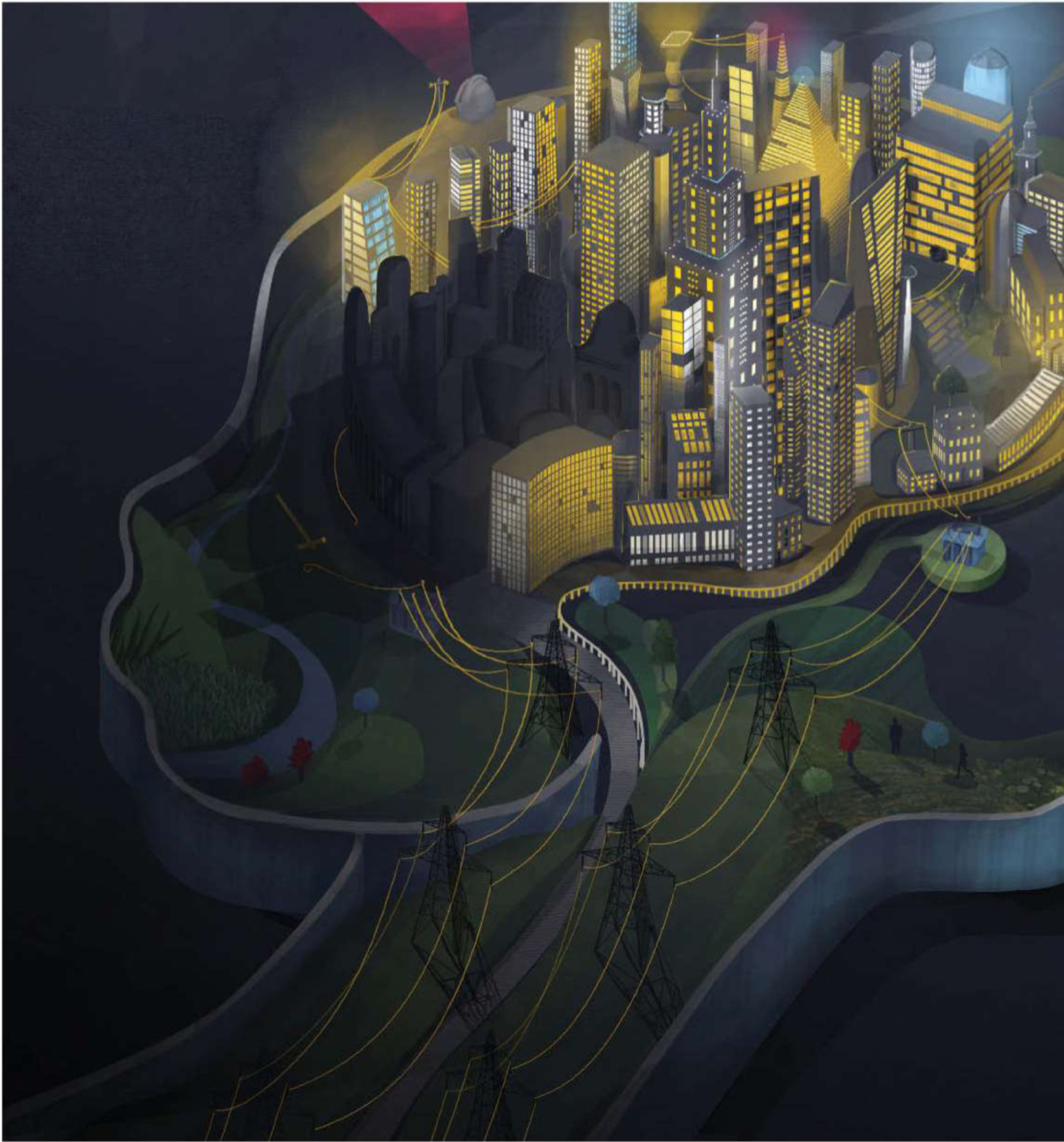
What drew you to the Arctic in the first place?

Adventure. I just love to be at sea and to see new things and work five steps ahead of everyone else. As a child I read all those adventure books, like Robert Louis Stevenson's, and I imagined myself as an adventurer. I'm joyful that it came about.

Why didn't you go to a tropical island instead?

I do that too. A tropical sunset with some flying fish is wonderful, but I am always drawn back to the ice. ■

Interview by Catherine Brahic



Meet your other brain



SAM FALCONER

RECENTLY, my friend's cable TV went out. She fiddled with the box: resetting, unplugging and re-plugging. When that failed, she called the cable company. They examined things at their end – and came up short. Frustrated, she retreated to another room, where she discovered her cat had ripped apart a piece of the wire. It wasn't the ends that needed fixing; it was the part in the middle.

A similar revelation is under way in neuroscience. For years, changes in the brain – whether from learning to ride a bike, taking a Prozac, or sinking into Alzheimer's disease – have been attributed to the activity of neurons and the small chemical junctions between them, called synapses. Targeting synapses is like fiddling with the connections at either end or calling the cable company. But ignoring the wiring in between may be a mistake.

"All ideas about communication and plasticity in the nervous system were focused on the synapse," says Douglas Fields at the National Institutes of Health in Bethesda, Maryland. That's starting to change, as he and other neuroscientists realise that neurons alone are not enough to explain our brain's plasticity – its ability to learn, adapt, and form new memories.

What it comes down to is myelin, the fatty sheath that envelops most neurons. We are used to thinking of it like insulation along a cable – allowing electrical impulses to zip along faster. But we are learning that this fatty layer is not like a wire's insulation, installed uniformly and left unattended. Instead, it is dynamic and autonomous, customising itself to match the brain's demands. The cells that produce it respond in real time to our cognitive needs: new insulation is laid down to help the brain master a skill; a frayed section can be replaced. What's more, these additions and renovations continue well into adulthood. This new kind of plasticity has come as a shock to many researchers. Bill Rebeck at Georgetown University in Washington DC has been a professor of neuroscience for over a decade, but when he heard about it last year, he was gobsmacked. "Wait, really?" was all he could mutter.

And plasticity is just the start. Because they are not nerve cells, which are notoriously hard to tinker with, we might be able to tweak them manually to give the brain an extra boost

when needed, or to help mend the damage behind conditions such as multiple sclerosis. It turns out a most vital part of our cognitive potential has been hiding in plain sight.

To better understand why myelin is so important, you need to look at how information travels around the brain. A neuron sends electrical impulses zipping down long projections called axons to the synapse, a small gap that chemicals called neurotransmitters travel across. These relay the signal to neighbouring neurons (see diagram, page 32). Myelin keeps the information tightly confined within the axon, allowing a speedy trip.

Wired for learning

The substance is thought to have evolved to allow animals to react quickly. But myelin does more than just speed up our reflexes, it is also crucial to learning, development and behaviour. "Ultimately it allows us to have clever brains," says William Richardson, who studies neuronal plasticity at University College London.

Hints about the role of myelination in cognitive abilities come from the way it is produced during our lifetime. A small amount is made as we develop in the womb, but after birth it takes off, and we see surges as infants learn to crawl, walk and talk. By about age 4, the rate of myelination slows, and teenagers still have the prefrontal cortex left to myelinate – an area crucial for planning and consideration of consequences. Until then, processing in the prefrontal cortex is slow and inefficient and teens remain precariously impulsive. The finer circuitry is complete by the time we reach our 40s, but from the 60s onwards the coverings start to fray and degenerate, which fits with the common experience of cognitive decline as we age. As myelin degenerates, the signals get fuzzier.

Until recently, scientists thought insulating the prefrontal cortex was the final hurrah for myelin. Plasticity was then down to the neurons, and synapses between them. For instance, the number of neurotransmitter receptors increase in a synapse the more that pathway is used, which enables the brain to adapt according to learning or experience. As a result, our quest to understand ➤

Inside your head, a mighty ally has been hiding in plain sight. It's time to make the most of your myelin, says **Teal Burrell**

SOCIAL NETWORKS

After the Romanian Revolution in 1989, the dismal reality of the country's orphanages was revealed: 170,000 children had been crowded into impoverished institutions, largely abandoned, and left without human contact. A few years later, even after being adopted into good homes, the children struggled with low IQ, depression, anxiety, and social and behavioural problems. Brain studies revealed the wiring between regions wasn't as efficient; the myelin was lacking.

Almost accidentally, Gabriel Corfas, now at the University of Michigan in Ann Arbor, discovered an analogous phenomenon in young mice. He was originally planning on studying something else – solo mice were a control – but the isolated mice turned out to be too interesting to resist. The oligodendrocytes of socially deprived mice looked deprived themselves, with scrawnier arms that didn't wrap as many times around the axons (see main story).

"Information is flowing more slowly along these circuits," says Corfas. "You could expect it would produce functional and behavioural problems." Just like the orphans, the mice had poor memories and problems interacting with other mice.

Social deprivation can cause problems in adults as well, but unlike in young animals, the damage seems reversible. Similar issues in friendless adult mice are reversed when they are given cage mates.

cognitive decline, and the potential for activities that boost brain power, has focused on grey matter, the part of the brain and spinal cord packed with the neuron cell bodies and synapses.

But Heidi Johansen-Berg at the University of Oxford began to wonder about white matter, the area of our brain that is rich in myelin-covered axons. "It seemed like an overlooked but obviously very important structure in the central nervous system," she says. It wasn't until 2009 that she could investigate, with the help of a new neuroimaging method called diffusion MRI, which accurately measures human white matter in the living brain.

To test her idea, Johansen-Berg turned to a 2004 study, which had found that learning a new skill such as juggling changed the density of grey matter – an example of classic synaptic plasticity. Johansen-Berg decided to recreate the study, and measure changes in white matter too. A group of volunteers agreed to learn how to juggle, and after six weeks, brain scans showed that their myelin had increased more than that of a control group who had no training (*Nature Neuroscience*, vol 12, p 1370).

"We saw a change not only in the grey matter but also in the underlying white matter pathways, suggesting that these pathways strengthen in some way as a result of experience," says Johansen-Berg. The changes to white and grey matter took place over different timescales, suggesting two separate

processes. Johansen-Berg thinks the increase in white matter would have enabled faster conduction along the circuits coordinating juggling. What's more, the effect was seen in everyone who learned to juggle, regardless of how good they became, which means it is the learning process itself that is responsible.

This was the first study to reveal that training can alter white matter in healthy adults, and it opened the door to a plethora of similar findings. Since then, numerous activities have been linked to extra myelin, from learning to read, to meditating, and learning a new skill like playing the piano or another language.

To investigate these changes more closely, Richardson turned to rodents. Rather than juggle, he made mice run on a complicated wheel, with rungs removed in a random

"This research might yield a wonder drug that speeds up the rate of learning"

pattern. Watching the struggling mice is a pitiful sight – their legs slip through the bars, their paws feel desperately into empty space. But after just a few days, they look like they've been doing it forever. So was myelin the key?

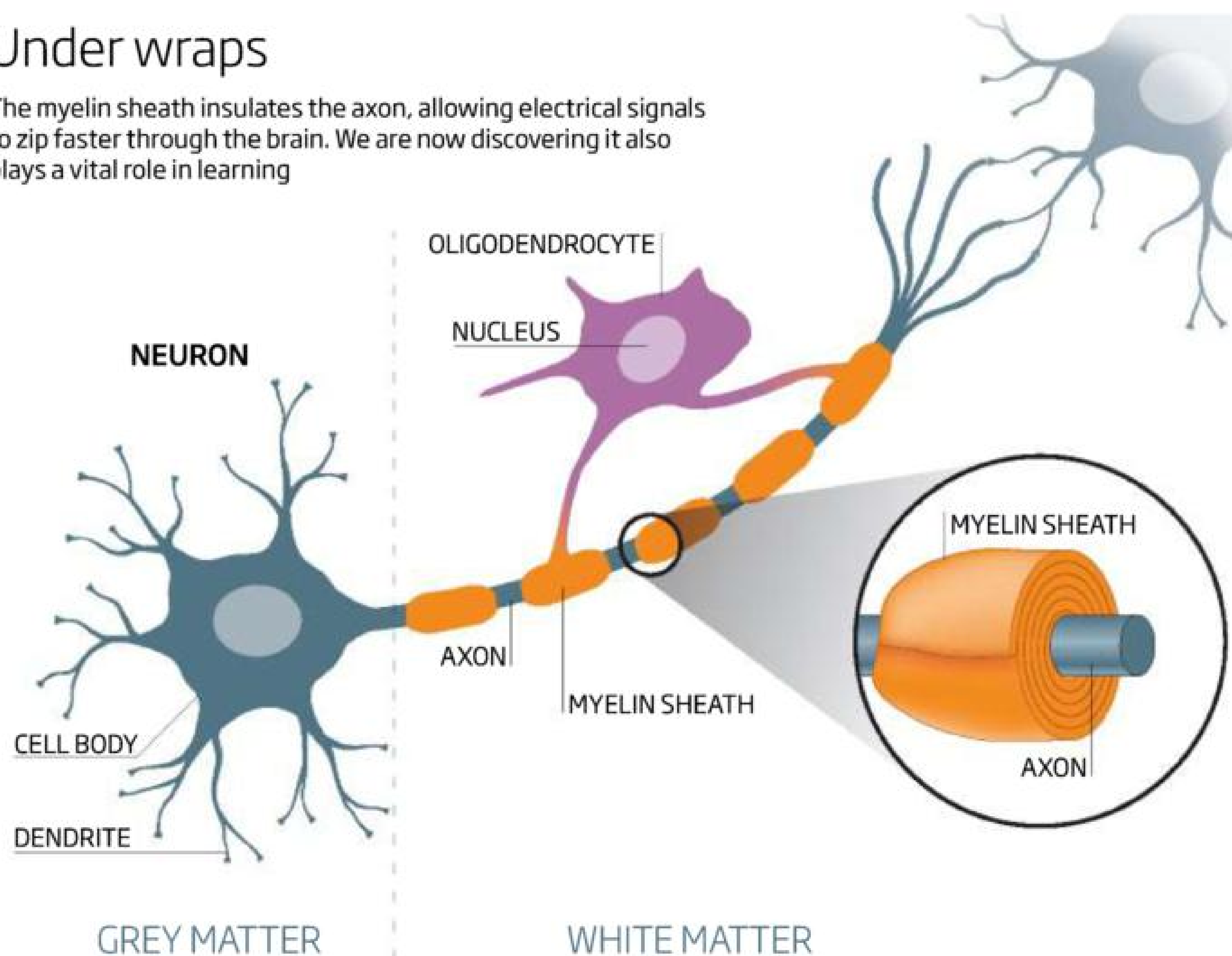
Myelin is formed by oligodendrocytes, octopus-shaped cells with long arms that wrap thin layers of fat 50 to 100 times around the axon, preventing electrical signals from slipping out, and expediting the conversation between brain regions (see diagram, left). The cells are made throughout life by oligodendrocyte precursor cells (OPCs), which tile the brain, ready to morph when needed.

When Richardson bred mice that couldn't produce oligodendrocytes – or new myelin – in adulthood, the mice weren't able to get used to the wheel, even after a week of practice.

Further proof of the essential role of myelin in learning complex skills came last year. Michelle Monje at Stanford University in California turned to another relatively new technology, optogenetics, which involves breeding mice with light-sensitive genes. This allows unprecedented control over neurons using pulses of light. Monje used it to activate a particular set of neurons that made the mice run in anticlockwise circles. After a while, they became slightly more efficient with the left paw, and when Monje inspected the brains of the mice, she found that new myelin had been laid down in these circuits. Crucially, she was able to show that repeatedly activating specific

Under wraps

The myelin sheath insulates the axon, allowing electrical signals to zip faster through the brain. We are now discovering it also plays a vital role in learning





Hit a home run and keep your brain insulation from wearing thin as you age

neurons led to changes in the surrounding myelin rather than changes within neurons, so it was this that was critical to making the circuits more efficient.

Richardson and Monje's papers, both published in 2014, distinguish myelin plasticity as a second type of plasticity – distinct from the better-known synaptic version. Although more studies will be needed in humans, the findings have important implications for learning and memory. Well-used pathways get more myelin, as shown in the juggling study, speeding up the signals and making the brain more efficient. Being more efficient, these pathways are also more likely to be used next time around. "It's not only that information is stored in the plasticity of synapses, but actually in the myelin as well," says Gabriel Corfas at the University of Michigan in Ann Arbor. If you are learning Mandarin, for instance, myelination would help you remember the right character faster and more intuitively. "This gives a new dimension to the amount of information and the types of information the nervous system can store," Corfas says. The importance of these and other non-neuronal cells has led Fields to term them our "other brain".

While we now know that stimulating the brain in various ways can boost myelin production, so too can the insulation be lost, emphasising that the brain is a "use it or lose it" organ. If electricity isn't flowing, the myelin can degrade, and this can lead to psychological and social problems (see "Social networks", page 32). If the brain were a city, and myelin the insulation on wires connecting the buildings, some parts would end up in the dark. A lack of myelin is implicated in conditions like autism, in mental illnesses such as schizophrenia, and in spinal cord and traumatic brain injuries.

And there is a further twist. It turns out that myelin production is in part controlled by packets of messenger chemicals that are relayed through the blood. Could we use these messengers to give struggling brains a boost, rather than trying to manipulate brain cells directly, which is notoriously hard?

That's the thinking behind the work of Richard Kraig, at the University of Chicago. His team discovered that small packets of proteins and RNA in the blood known as exosomes influence myelin production.

Many types of cell release exosomes as a way of delivering specific messages to other cells: they are part of the body's vast communication network. Kraig began to wonder about the roles of exosomes on brain function after reading that transferring the blood of young mice into old mice can reverse their cognitive decline.

UNTANGLING THE WIRES

Your instant guide to white matter

- **Myelin** Fatty layers of insulation around the main tendril of a nerve cell – the axon. Produced by cells called oligodendrocytes
- **White matter** The part of the brain and spinal cord packed with myelin-covered axons. It appears white because of the fat in myelin
- **Grey matter** The part of the brain and spinal cord rich in cell bodies of neurons and synapses
- **Synapses** The narrow spaces between neurons where chemical neurotransmitters are released, transmitting information to the next neuron
- **OPCs** Oligodendrocyte precursor cells – turn into oligodendrocytes
- **Oligodendrocytes** Octopus-like cells that produce myelin around a nerve fibre

He has now shown that exosomes produced in the blood are taken up by OPCs in the brain. Their message is the "trigger to make the myelination go", says Kraig. That raises the exciting possibility that a blood transfusion packed with the right exosomes could help treat multiple sclerosis (MS), in which myelin is attacked by the immune system.

OPC-regulating exosomes are dispensed whenever the brain is stimulated in new ways, such as during exercise and learning. They may be one reason why physical and mental activity help ward off diseases like Alzheimer's. But while advice to exercise the body and mind is not new, for many people it is not that simple – if you have MS, for instance.

Kraig hopes that treating people with donor exosomes might improve myelination enough to enable them to exercise, and thus boost exosomes and myelination themselves.

Another disease, amyotrophic lateral sclerosis (ALS), is not normally associated with myelin. It is characterised by the death of neurons that control muscles. But in 2013, Dwight Bergles at Johns Hopkins University in Baltimore, Maryland, showed in mice that oligodendrocytes die before the neurons. Late in the disease, more than half of them had died. "This is a massive reorganisation of myelin. It is very stressful for neurons and can induce them to degenerate," Bergles says.

He has now found that in people with ALS, OPCs seem to have difficulty converting to oligodendrocytes. The key to an ALS cure may lie in preventing the initial oligodendrocyte loss, or helping OPCs to morph properly.

There is still much to be worked out, and many of the animal studies need to be confirmed in humans. But as Corfas said at the Society for Neuroscience conference in Washington DC last November, "it's an exciting time. The way we think about myelin is changing." Indeed, if we can uncover enough, this type of research might even yield an actual wonder drug, says Richardson, one that makes us smarter, speeding up the rate of learning.

In the meantime, the message is clear. "Keep learning, keep your mind active," Richardson says. Kraig recommends learning new things, like a new piano piece, as well as keeping up with ordinary activities like taking a walk. If it's an unfamiliar route, with changing scenery and the requirement to memorise the way home, that's all to the good. So embrace a new hobby. And then another. It should help keep the electricity flowing a little better, a little longer. ■

Teal Burrell is a science writer based in Washington DC

Turned to stone

Jeff Hecht and Michael Le Page pick out seven of the most amazing fossils ever discovered

Fossils can be amazing in many ways. There are unbelievable creatures like *Atopodentatus*, a marine reptile with a second row of teeth splitting its skull where its nose ought to be. Or *Helicoprion*, the shark with a circular saw for slicing up prey. There are the fossils that transformed our view of ancient life, like *Archaeopteryx*, with its strange mix of reptilian and bird-like features.

Then there are fossils with features we never expected to be preserved. Dinosaur skin imprints. Beetles whose iridescent shells still shimmer with rainbow colours. Ancient fish in whose petrified eyes the light-detecting rod and cone cells can be seen under a microscope. Yet other fossils capture our imaginations because they are so mysterious, like the enigmatic embryo-like things from 600 million years ago that don't match anything we know.

But for us, the most amazing give us a very rare glimpse not just of what animals existed, but what they were doing – fossils that transport us back in time to long-lost worlds.

THE FIGHTING DINOSAURS

Discovered: Gobi desert, Mongolia, 1971

Age: 74 million years

Location: Mongolian Dinosaur Museum, Ulan Bator

They will remain forever locked in mortal combat. The *Velociraptor* has sunk its deadly foot claw deep into the neck of the herbivore, a boar-sized creature called *Protoceratops*. This vicious attack may have hit the carotid artery – a lethal blow.

But the *Protoceratops* fought back. It has thrown the *Velociraptor* to the ground before it, and its jaws are locked on to the predator's right arm. The bite appears to have broken the *Velociraptor*'s arm. "There is no doubt these animals were

fighting," says Mark Norell of the American Museum of Natural History in New York, who studied the fossil while it was on loan to the museum. "There is nothing else like the fighting dinosaurs, which captures direct evidence of a single instant in time."

What happened next? One possibility is that a sand dune collapsed on them while they were still fighting for their lives. Norell thinks heavy rains had destabilised the dune, so it flowed quickly and smoothly over the pair as they fought. Elsewhere in Mongolia, he says, animals have been found trapped in their burrows by similar flows.

Or perhaps the plant-eater bled to death from the blow to its carotid artery, trapping the injured *Velociraptor* under its heavy body.

1. *The fighting dinosaurs*
2. *Big Mama*
3. *Snake eating baby dino*
4. *The mating turtles*
5. *Ichthyosaur giving birth*
6. *Fish catching fish-catching pterosaur*
7. *The Paluxy trackways*



DAVID CLARK/DINOSAURS ALIVE/IMAX FILM/GIGANT SCREEN FILMS

When the predator eventually died, too, a sandstorm covered both bodies, suggests Ken Carpenter of the Utah State University Eastern Prehistoric Museum.

He points out that the *Protoceratops* is missing both forelimbs, the left hind limb and the end of its tail. This is hard to explain if they were buried alive, but could mean that scavengers found the pair dead or mortally wounded. The tight S curve of the *Velociraptor*'s neck also suggests it died before it was buried, Carpenter says. Various combinations of the two scenarios are feasible too – perhaps scavengers dug down to snatch the missing parts after the two were buried alive.

What really matters, though, is that the pair were preserved at all.

Deadly duels between dinosaurs must have been an everyday event. The formidable weaponry of many meat-eaters suggests they were active predators rather than mere scavengers, but there is very little direct evidence of this. A tooth fragment found embedded in a healed tail wound,

“It looks like a freeze-frame from a dinosaur drama-documentary”

for instance, is the best evidence that *T. rex* hunted live prey.

So to find two dinosaurs locked in combat, in what looks like a freeze-frame from a dinosaur drama-documentary, is absolutely extraordinary. “It’s one of the best

discoveries ever,” says Carpenter.

“It’s just so ridiculously amazing,” agrees palaeontologist David Hone of Queen Mary University of London. It is surprising that a *Velociraptor* seems to have attacked an animal as big as the *Protoceratops*, he says, as most predators only tackle prey smaller than themselves.

The movie *Jurassic Park* made the name *Velociraptor* famous, but the terrifying predators in the film more closely resemble a much larger species called *Deinonychus*. *Velociraptor* was in fact quite small: 2 metres long thanks to its tail but just half a metre tall. There is no evidence these feathered fiends made up for their small size by hunting packed in hunts either. The *Protoceratops* was also about 2

metres from nose to tail tip, but much more heavily built. “The *Protoceratops* was three, four, five times the weight of the *Velociraptor*,” says Hone.

Is it still the only example of its kind, though? A fossil found in 2006 in the Hell Creek formation of Montana contains bones from a tyrannosaur-like predator and a *Triceratops*-like plant eater. It was dubbed the “duelling dinosaurs” by its private owners and put up for auction for \$7 million in 2013, but did not sell.

Yet the Hell Creek rocks were deposited in flowing water, so Norell thinks it more likely that the two dinosaurs were washed together by a flood than that they fought to the death. For now, then, the Mongolian fighting dinosaurs remain unique. ➤

AMAZING FOSSILS

BIG MAMA

Discovered: Gobi desert, Mongolia, 1994

Age: 83 to 66 million years

Location: Mongolian Dinosaur Museum

The first oviraptor was discovered in Mongolia in 1922. It was found near a nest of what appeared to be *Protoceratops* eggs – hence its name, which means “egg thief”.

In 1993, however, Mark Norell of the American Museum of Natural History found a fossilised embryo in an identical egg. He recognised it as a kind of oviraptor, suggesting the original thief was in fact a parent.

The following year, Norell was back in Mongolia when he spotted bones and claws protruding from the sand. But Norell had limited space in his trucks. The bulky fossil might have stayed where it was had team member Luis Chiappe not injured his foot. He wanted to collect a specimen rather than walk around searching for more.

A day or two later, Chiappe drove up to Norell and another team member, Jim Clark. “We found something you won’t believe,” Chiappe told them.

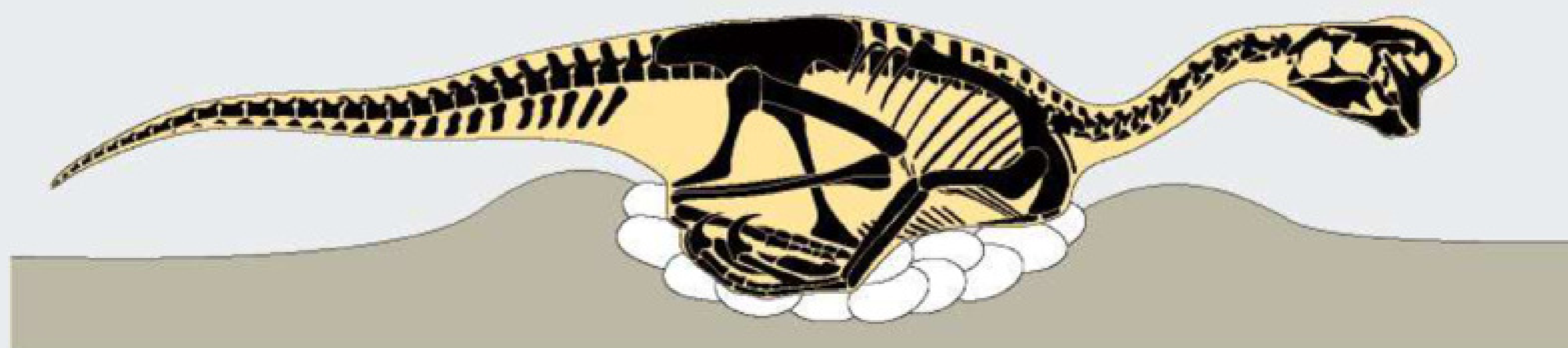
The skull of the dinosaur was missing. But much of the rest of the skeleton was present – and under it there was a nest of eggs. “It’s clear it was sitting on the nest,” says Clark, now at George Washington University in Washington DC. What’s more, it was sitting in exactly the same position birds adopt when incubating their eggs.

There had been hints before that some dinosaurs brooded their eggs, but the discovery of Big Mama was conclusive proof (*Nature*, vol 378, p 774). She was probably buried alive when a sand dune collapsed after heavy rains.



MICK ELLISON/AMERICAN MUSEUM OF NATURAL HISTORY

The top part of Big Mama is missing, but it's clear she was brooding her eggs



1. The fighting dinosaurs
3. Big Mama
2. Snake eating baby dino
4. The mating turtles
5. Ichthyosaur giving birth
6. Fish catching fish-catching pterosaur
7. The Paluxy trackways

SNAKE EATING BABY DINO

Discovered: Gujarat, India, 1986

Age: 68 million years

Location: Geological Survey of India

Unlike some dinosaurs, the giant, long-necked sauropods did not care for their eggs. Adults have never been found near nests, so it seems that sauropod hatchlings had to fend for themselves from the start. And that left the way clear for predators to feast on them as they emerged.

One of these predators was a 3.5-metre-long snake called *Sanajeh indicus*. Towards the end of the age of the dinosaurs, one decided to raid a nest of a sauropod eggs, perhaps attracted by the noise of hatchlings breaking out of their shells.

Sanajeh could not open its mouth wide like modern egg-eaters and other snakes, says Jeffrey Wilson of the University of Michigan in Ann Arbor, who helped describe the fossil (*PLoS Biology*, e1000322). The eggs were 14 centimetres wide, so the snake could not down them whole nor break the shells, which were over 2 millimetres thick.

Instead, the snake coiled itself around the eggs and waited for a meal to emerge. But just as it was about to gorge on a half-metre-long hatchling, a landslip buried the nest, snake and all.

The nest was originally found by Dhananjay Mohabey of the Geological Society of India in 1986. Another palaeontologist, Sohan Lal Jain, spotted a few snake vertebrae but his observation was not followed up. In 2001, Wilson also noticed the vertebrae when Mohabey showed him the fossil. He arranged for it to be taken to the University of Michigan, where much more of the snake was uncovered.



SCULPTURE: TYLER KELLOR PHOTO: XIMENA ERICKSON



2010 WILSON ET AL



2012 THE ROYAL SOCIETY

No prizes for guessing what this pair were up to

THE MATING TURTLES

Discovered: Messel Fossil Pit, Germany, 1987

Age: 47 million years

Location: Senckenberg Natural History Museum, Frankfurt

The French famously call it the little death. But for this pair of mating turtles, the little death became a big death. As they sank down into the depths of a lake in their post-coital bliss, they reached toxic waters and perished. Their fossil remains leave no doubt that they died in the act of mating.

Around 30 fossils of mating insects have been found, most of them caught in amber. But the turtles, *Allaeochelys crassesculpta*,

“The turtles are the first ancient vertebrates to be fossilised in the act”

are the first ancient vertebrates to be caught in the act. They lived in a volcanic lake in what is now Messel, Germany. The deep water was both anoxic and toxic, creating a death trap.

Allaeochelys belonged to a group of turtles with skins porous enough to absorb oxygen from water. That made them especially vulnerable to the toxins and the lack of oxygen, says Walter Joyce of the University of Fribourg in Switzerland. The turtles are particularly common in the Messel fossil pit, with 51 collected over the past few decades, including 12 pairs.

Joyce thinks at least nine of the pairs were mating (*Biology Letters*, vol 8, p 846). So perhaps alone among vertebrates, the *Allaeochelys* turtles in this lake had a unique tendency to be fossilised in the act.



RYOSUKE MOTANI



2012 FREY, TISCHLINGER

FISH CATCHING FISH-CATCHING PTEROSAUR

Discovered: Solnhofen, Germany, 2009

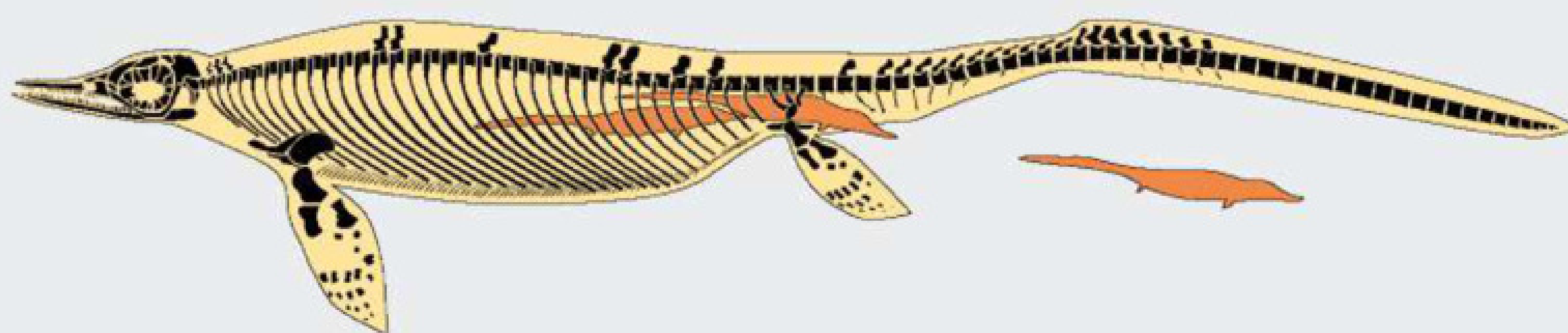
Age: 155 million years

Location: Wyoming Dinosaur Center, Thermopolis

The pterosaur flew just above the water of the tropical lagoon. Snap! It snatched a small, herring-like fish from the water and began to swallow it. But the noise attracted a predator. Up popped *Aspidorhynchus*, a sleek fish about 60 centimetres long. It leapt out of the water and grabbed the pterosaur by its left wing as it was flying. All three animals then splashed down into the water.

But the *Aspidorhynchus* had bitten off more than it could chew. It didn't have wide jaws and cutting teeth capable of dealing with such large prey. Its jaws were narrow, ending in a pointed snout, and were lined with lots of small, sharp teeth best suited to catching other fish. These teeth became entangled with the tough fibres, or aktinofibrils, that reinforced the wing membranes of the pterosaur, *Rhamphorhynchus muensteri*.

As the fish tried to shake itself free, it damaged the bones of the wing. During the struggle the



ICHTHYOSAUR GIVING BIRTH

Discovered: South Majiashan, China, 2011

Age: 248 million years

Location: Anhui Geological Museum, Hefei, China

Birth is a dangerous process, and for this very ancient ichthyosaur mother it went terribly wrong. She was carrying at least three offspring. One was found under the mother's body. The third was still inside her, waiting to be born. And the second was halfway out

of the birth canal, making this fossil unique.

Only part of the mother was found because the team that collected the rock in 2011 had no idea it contained ichthyosaurs – they were after a predatory fish. The ichthyosaurs came to light only when the fossil was being prepared in the lab the following year. By then it was too late to recover the rest of the mother, says team member Ryosuke Motani of the University of California at Davis. But they found other fossils

of the same species, *Chaohusaurus*, which were around a metre long.

There is another fossil of an ichthyosaur that might also have been giving birth. But in this case the embryo is almost entirely outside the body, and some think that it was expelled by gases as the mother, a *Stenopterygius*, decomposed on the seabed. Motani thinks this scenario is unlikely for the *Chaohusaurus*, since it had given birth to one offspring and the second was on its way out.

1. *The fighting dinosaurs*
2. *Big Mama*
3. *Snake eating baby dino\$*
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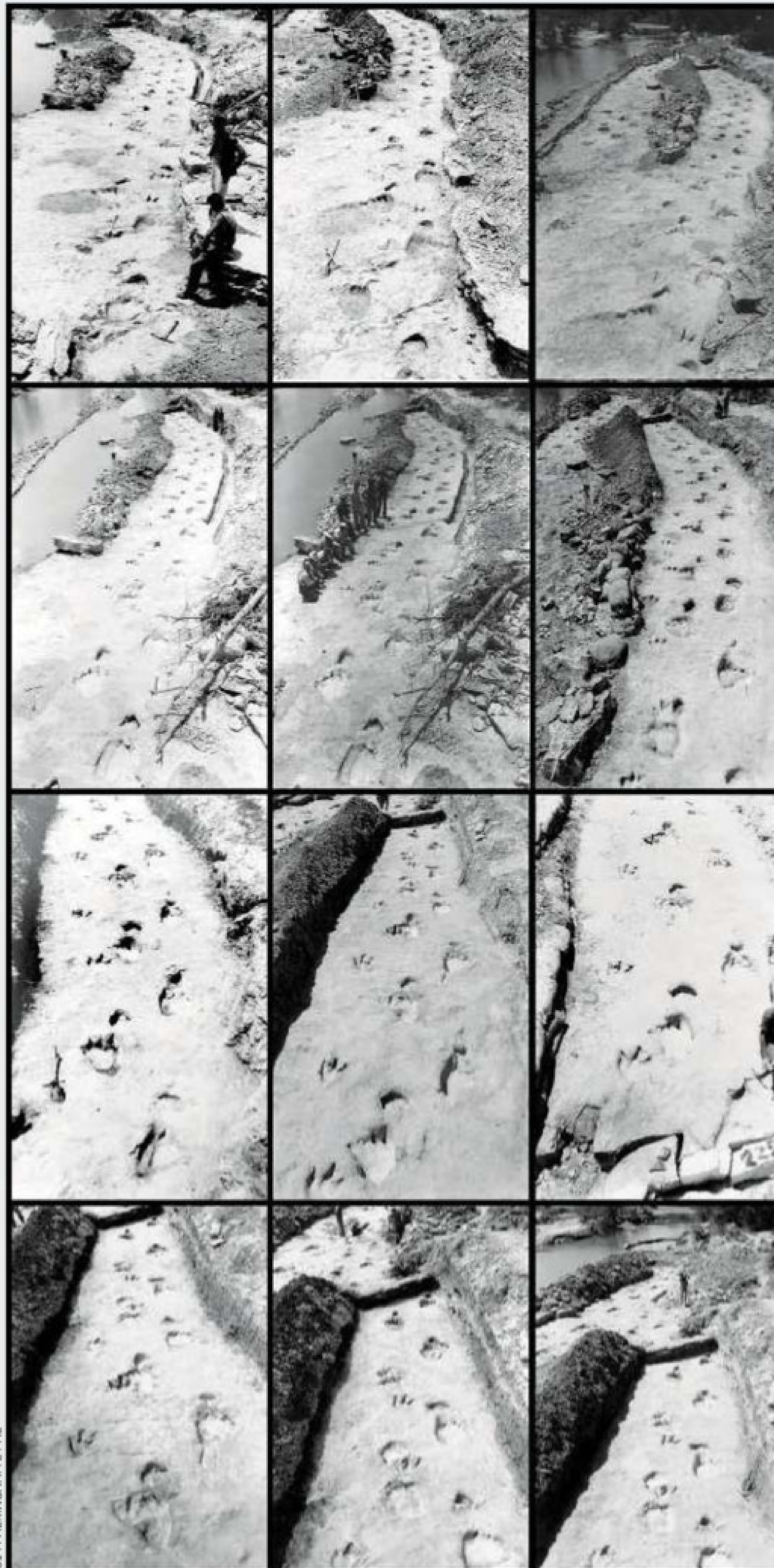


Two predators, two prey, but only three animals

pterosaur drowned, with the small fish it had caught halfway down its throat. The *Aspidorhynchus* continued its futile struggle to disentangle itself, but sank into deeper water low in oxygen and died. The bodies of all three animals ended up on the bottom of the lagoon and there they remained, beautifully preserved, until they were dug up 150 million years later.

This is the scenario proposed in 2012 by Eberhard Frey of the Karlsruhe State Museum of Natural History in Germany, who studied the fossil (*PLoS One*, e31945). We cannot be sure about all the details, but there's no doubt that the pterosaur had just caught a fish, only to be caught by a fish itself. "The attack was a lethal error on the side of *Aspidorhynchus*," Frey says. He has proposed that the pterosaur was skim-feeding – flying along with its lower beak in the water – before it was caught.

But Mark Witton at the University of Portsmouth, UK, author of the book *Pterosaurs*, says no pterosaur had any of the specialisations of skim-feeding birds, such as a reinforced skull to withstand high-speed impacts. It is more likely they flew low and dipped their jaws into the water to grab prey.



2014 FALKINGHAM ET AL

Thrill of the chase: are these the tracks of a predator and its giant sauropod prey?

THE PALUXY TRACKWAYS

Discovered: Glen Rose, Texas, 1938

Age: 111 million years

Location: Part at the American Museum of Natural History

The massive sauropod fled along the shore closely pursued by a huge predator similar to *T. rex*. The trail of footprints they left behind has survived for over 100 million years.

Exactly what happened is not clear. Roland Bird of the American Museum of Natural History, who discovered the footprints in 1938, thought they showed the predator running alongside the sauropod and at one point sinking its teeth into it, missing a step as it was lifted off the ground.

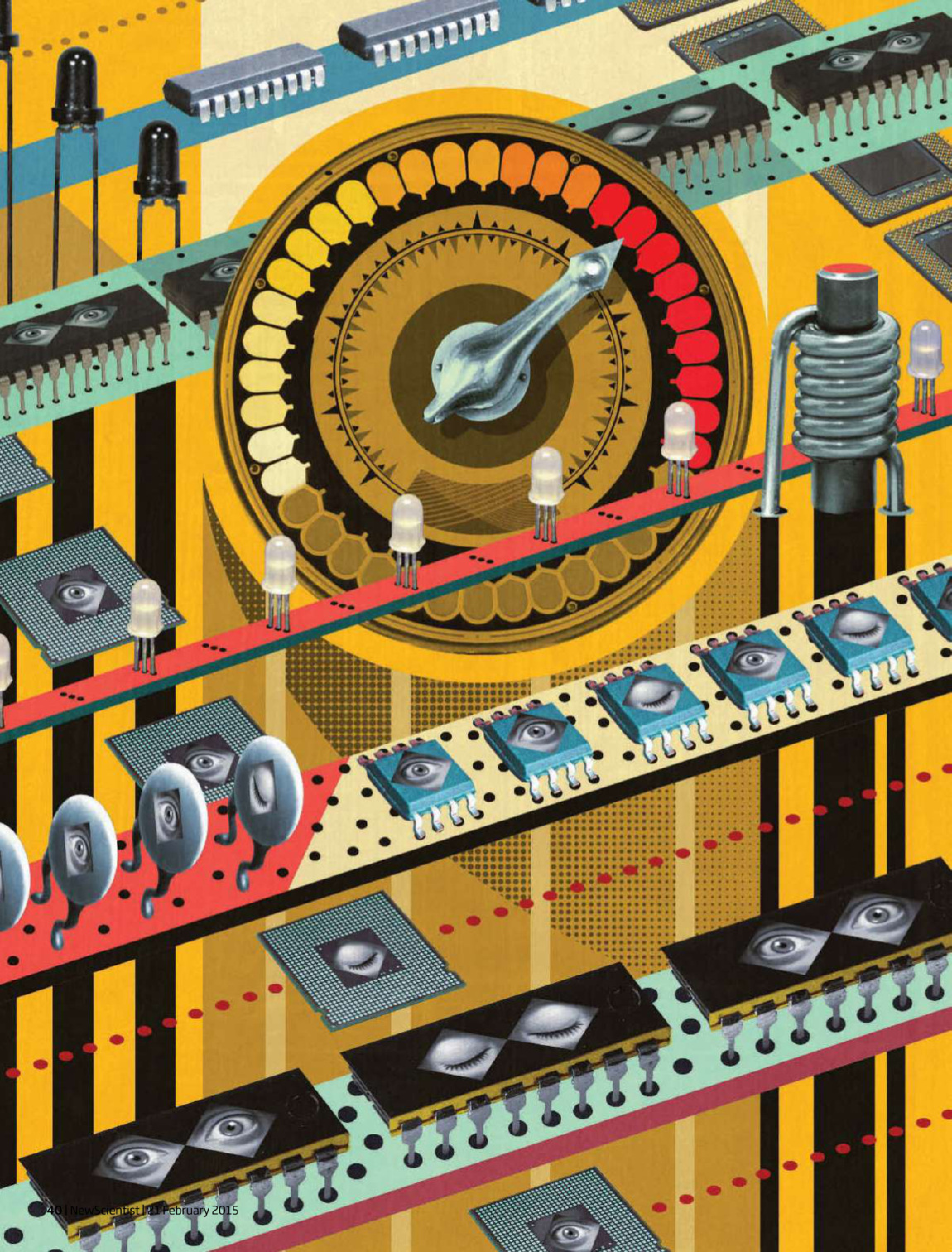
Researchers are more cautious today. There is no clear evidence of such an attack, says James Farlow of Indiana University-

"It seems as if the predator was at least stalking the massive sauropod"

Purdue University in Fort Wayne, who has studied the trackway. But the predator and sauropod tracks run parallel, and at one point turn together. So it seems the predator was stalking the sauropod, not just heading the same way.

There is a whole series of such tracks along the Paluxy river in Glen Rose, Texas. Many sauropods, possibly a large group, walked in one direction. Predatory theropod dinosaurs went both ways parallel to the sauropod tracks, suggesting all were walking near a shoreline. ■

Jeff Hecht is a consultant for *New Scientist* based in Boston
Michael Le Page is a feature editor for *New Scientist*



Computer speeds stalled a decade ago. Is it time to reboot our ideas, asks Matthew Chalmers

TEN years ago, computers stopped getting faster. Stroking your sleek smartphone or latest laptop, this may seem a rather implausible statement. Surely there's no contest between it and a decade-old desktop?

That's true – in a way. But even if computer chips weren't made of silicon, the comparison would be built on sand. Continually increasing computing power used to rest on a solid foundation of ever smaller, faster chips. In the past decade, though, it has become a case of using more chips, less efficiently. Chip speed stalled sometime around 2004.

You don't need to be the type who camps outside stores for the latest gizmo to be concerned. Since the silicon chip's invention some 40 years ago, exponentially increasing computing power has become a bedrock of economic and social development. Believe the prophets and today we stand on the brink of a further information revolution, one where the ability to crunch huge data sets quickly and cheaply will provide us with a cornucopia of benefits. These include everything from better weather forecasts to personalised drugs to an "internet of things", in which items as diverse as refrigerators and clothes will exchange streams of life-improving data in real time.

Only if the hardware can keep up. "People think 'big data' is going to kick in and be the second IT revolution, but you need the raw power, the chips," says Glenn Martyna, a researcher at IBM. First, someone needs to satisfy our need for speed.

It's 50 years ago this April that Gordon Moore, co-founder of the chip company Intel, first predicted that computing power would roughly double every two years. More precisely, Moore said that the number of transistors in a single circuit or processor would double every 18 to 24 months.

Perhaps physicists' greatest invention, the transistor is a switch made of a semiconductor such as silicon. These materials are normally insulators, but start conducting if you apply a small electrical voltage. This switching behaviour allows digital information to be stored and processed in the form of strings of 1s (current on) and 0s (current off).

Although chip evolution has come in fits and starts, what became known as Moore's law proved pretty accurate (see "When the chips are down", pages 42–43). Intel's "4004" silicon chip, which kicked off the PC revolution in 1971, packed in 2300 transistors, each 10 micrometres across. Today's cutting-edge chips contain up to 5 billion, each roughly 20 nanometres across – the width of a couple of hundred atoms. There's still some room at the bottom, too: it's only at about a nanometre across that this sort of transistor architecture would be expected to become unreliable, thanks to quantum-mechanical effects such as electrons tunnelling through seemingly impenetrable barriers.

For most of the past half-century, the momentum of miniaturisation has delivered the goods. Smaller transistors have meant shorter distances for electrons to travel, less time to switch state and more bang for your computing buck. By the early 1980s, the first PCs were being marketed trumpeting maximum transistor-switching speeds – known as chip clock rate – measured in megahertz, or a million cycles a second. In 2000, the first gigahertz processors were announced with similar fanfare. By 2003, the Intel Pentium 4 HT chip was working with a clock rate of 3 gigahertz.

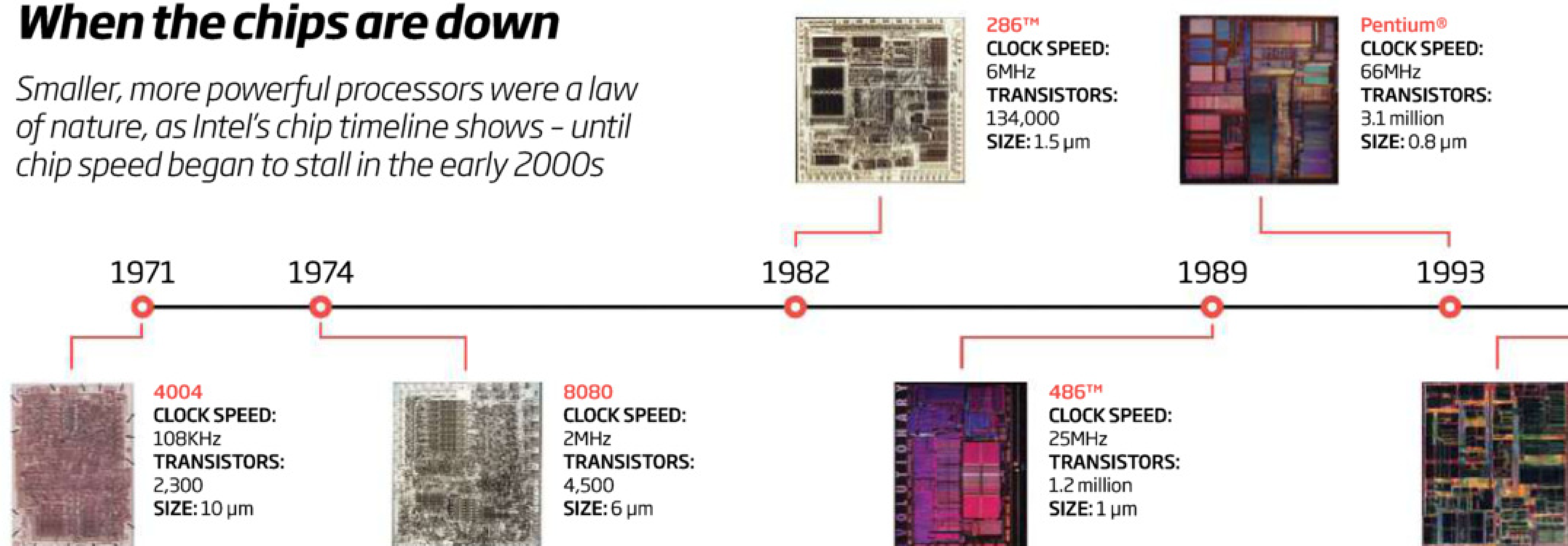
Heat death

And since then? Very little. As of 2015, the fastest central processor chips available for personal electronic devices still have clock rates largely hovering around 3 GHz.

The reason is more steam age than silicon age: heat. Billions of transistors switching billions of times a second create billions and billions of tiny puffs of heat, adding up to a huge amount of waste energy that must be transported away from a tiny area. That can only happen so fast, and a decade ago we hit thermodynamic limits on the speed of heat disposal. Individual transistors have continued to get smaller, and tweaks to their architectures – for example "multi-gate" transistors that can be more sensitively controlled using more than one voltage – have made them faster and more efficient. But to avoid the chips melting or exploding, each one has had to work less, throttling the overall chip speed. "These guys are still shrinking those transistors, but the belief that clock speeds go hand in hand with this miniaturisation is now over," says Todd Austin at the University of Michigan in Ann Arbor. ➤

When the chips are down

Smaller, more powerful processors were a law of nature, as Intel's chip timeline shows – until chip speed began to stall in the early 2000s



So it's not that Moore's law is broken, just that we aren't reaping the rewards as we used to. In the past decade, firms such as Intel have kept things going by using more transistors, but engineering them so that at any one time most of them aren't operating. "Multi-core" chips split computing tasks over different areas to provide more processor wow, while spreading the pesky power issues out.

But this approach, too, is reaching the end of the line. The more cores a processor has, the more time and energy it costs to communicate between them, eventually negating any gains.

Meanwhile, demand continues to rise apace. The IT research company Gartner has estimated that more than 25 billion smart devices will be beaming data to and from the "cloud" – massive central processor farms – by 2020. Beyond that, the vision is of a nexus of devices in our hands and in central server farms that work in tandem to perform increasingly data-heavy real-time analysis of everything from our environment, health status and online behaviour to how traffic is moving and the contents of our fridges.

This amounts to a huge additional burden on chip performance. Smartphones are already getting uncomfortably warm, and server farms across the world consume as much power as Japan, says Martyna. They are increasingly moving to colder climes, taking advantage of lower ambient temperatures to dissipate chip heat more quickly. "The industry always saw this point coming, but it took a while for people to wake up to how serious it was," says Martyna.

In the US, one reaction has been the creation of the Semiconductor Technology Advanced Research Network, or STARnet. A collaboration between academic labs and major commercial chipmakers coordinated by the US government agency DARPA, it is funded to the tune of almost \$200 million. It aims to look at computing in the round, finding out where efficiency can be improved all the way from underlying physical processes and materials to the smooth interaction of computer hardware and software.

Easy wins

Austin heads up one of six sub-projects, the Center for Future Architectures Research (CFAR). It is looking at ways to deal with huge volumes of data without abandoning 50 years of silicon development. One focus is on extending the reach of graphics processing units, or GPUs, which were invented to satisfy the information-intensive needs of computer game graphics. Unlike a computer's central processor, which has to perform many varied tasks in unpredictable sequences according to a user's demands, a GPU specialises in doing the same job – rendering the millions of pixels of a moving image – in parallel over and over again. This ability can also be used to speed up other computational problems that have a similar parallel nature, and Austin and his colleagues are looking at ways to combine multiple GPUs to make them useful for a wide range of general computing tasks.

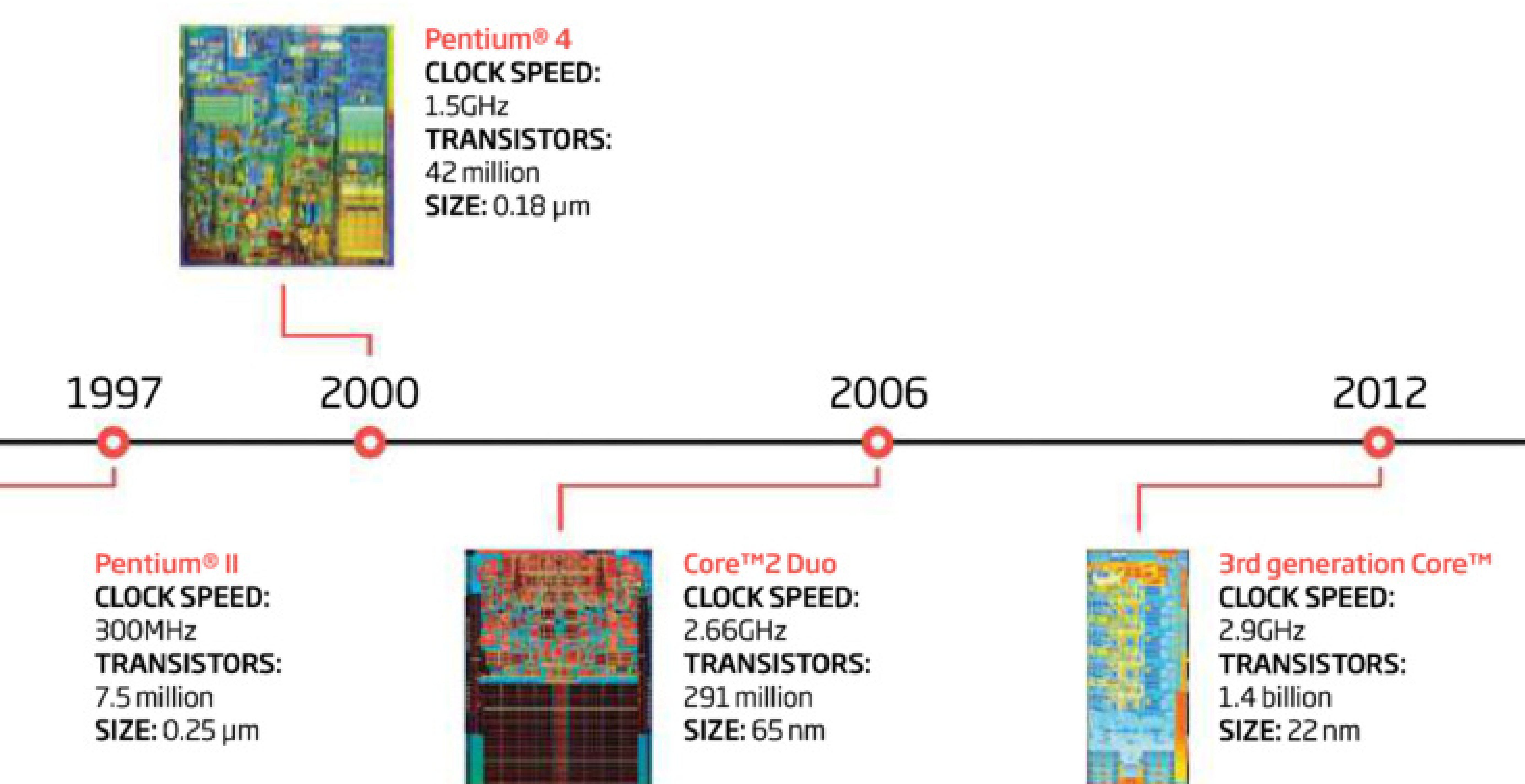
Another potential easy win, especially in multi-core processors, is to increase

transport speeds between chip components. One way to do that is to change the material used to make the connectors. In the late 1990s, the chip industry moved from aluminium to copper connectors, which were faster and much cheaper, without consumers noticing, says Thomas Theis of IBM. Everyone's favourite wonder material graphene – a one-atom thick form of carbon that conducts blisteringly fast – is a strong contender for the next leap. Or we could skip wires altogether and get chips to communicate using light. IBM researchers have suggested this could be a practicable way of communicating between cores by the end of the decade. Others think this is optimistic.

CFAR's approach to the same problem is somewhat different. Many common computational tasks, for example accessing databases, require the central processor and the computer's long-term memory to interact constantly, bouncing signals back and forth. By analysing how a computer's software manages this data exchange, chips can be designed to minimise the distance signals travel, and thus the heat they expend – or software can be designed to make more efficient use of the chip architecture.

Such gains will be welcome, but they skirt the central issue: transistor performance. For a more radical speed-up, we might need to rethink this fundamental unit of computing.

Martyna and IBM are placing some of their money on a very different transistor technology, the basics of which have been around for a century or more: piezoelectrics.



These are materials that change from conductors to insulators when subjected to mechanical strain. In 2008, Martyna was one of the first to discover that the voltage to switch the state of these materials is much lower than to switch a semiconductor such as silicon. The win is potentially a 100-fold reduction in power consumption and a 10-fold increase in processor speed.

The challenge is getting the things to work reliably at the nanoscale, where small imperfections on a material's surface can

"We've only explored a tiny fraction of what is possible for computing"

make big differences to its performance. IBM and others are now collaborating with a series of European metrology institutions to develop the necessary technology within a €4 million EU-funded project called Nanostrain. It's so far, so good, says project member Markys Cain of the UK's National Physical Laboratory: switching has been demonstrated successfully at a scale of 100 nanometres, with further size reductions planned.

It's not the only approach to reduce the power consumption of individual transistors. Another is spintronics, which takes advantage of a property of electrons called spin. Each electron has two possible spin states – up and down – which can be used to encode each bit of data. Flipping between these states takes much less power than switching a current on

and off. It's a principle that has been used since the mid-1990s to improve the performance of memory storage on computer hard drives, and another STARnet project, the Center for Spintronic Materials, Interfaces and Novel Architectures, aims to build on prototype spin transistors to extend that success to processors. Part of the problem is to find the material that enables the most efficient spin switching, and get that switching to work at room temperature.

Another alternative is to harness the power of quantum tunnelling. This process is generally seen as a hurdle to future miniaturisation: if transistor gates get too thin, electrons can disappear from one side and reappear on the other, ruining the switching. But the ability to control the process would make it possible to switch using far less power.

Tunnelling transistors have been made in the lab, but a new generation of incredibly thin "two-dimensional" materials, among them graphene, promise much greater control. Electrons have to burrow through much less material in such structures, potentially improving switching speed. Niftier transistors have also been fashioned by introducing carbon nanotubes into conventional transistors, although it is difficult to "grow" large numbers of nanotubes while maintaining consistency in their properties. Helping such developments along is the aim of yet another STARnet institution, the Center for Low Energy Systems Technology.

The sheer variety of approaches getting serious funding shows how earnestly the problem is being taken – and also how difficult

it will be to nominate a successor to existing technologies. "You always have to ask the same question: can you put 2 billion of these things on a chip, and can you scale them down further, because that's what provides value," says Austin. Semiconductor plants cost billions of dollars and have to be reconfigured at huge costs each time the industry moves down a transistor size. That sort of shake-up will only make sense if there is a compelling selling point – and mass demand – for the devices that emerge from new chip designs.

And the past decade might show us that speed isn't everything. "Why aren't consumers more angry that their computer isn't getting any faster?" asks Cain. One answer is that, to an extent, we have been content to trade in speed for functionality. The ability to put billions of transistors on a chip has given us amazing computing power that we can hold in our hands, but recently it's become more about faster and bigger memory, longer battery life and gizmos such as cameras and speakers.

As our world becomes more and more wired, the efficiency of a computer's interaction with other systems, for example our own bodies, will become more crucial to its overall performance. That leads Austin to wonder whether it might be time to say goodbye to Moore's law as the prime yardstick of computing progress. That wouldn't be the end of computing, just the end of a particular type of computing where miniaturisation and more power delivers more value.

Then again, predicting the future of technology is a notoriously fraught business. Few people half a century ago could have predicted what the progression of Moore's law has already brought, or what we would use all that computing power for. Perhaps 50 years from now we will have cracked the problem of quantum computing, which fully harnesses the weird correlations of quantum physics to deliver monumental low-power speed. Or perhaps we will have computers that work more like brains, processing data not in digital, but in analogue form; or electronics so efficient that they can run on sunlight or even moonlight, says Theis.

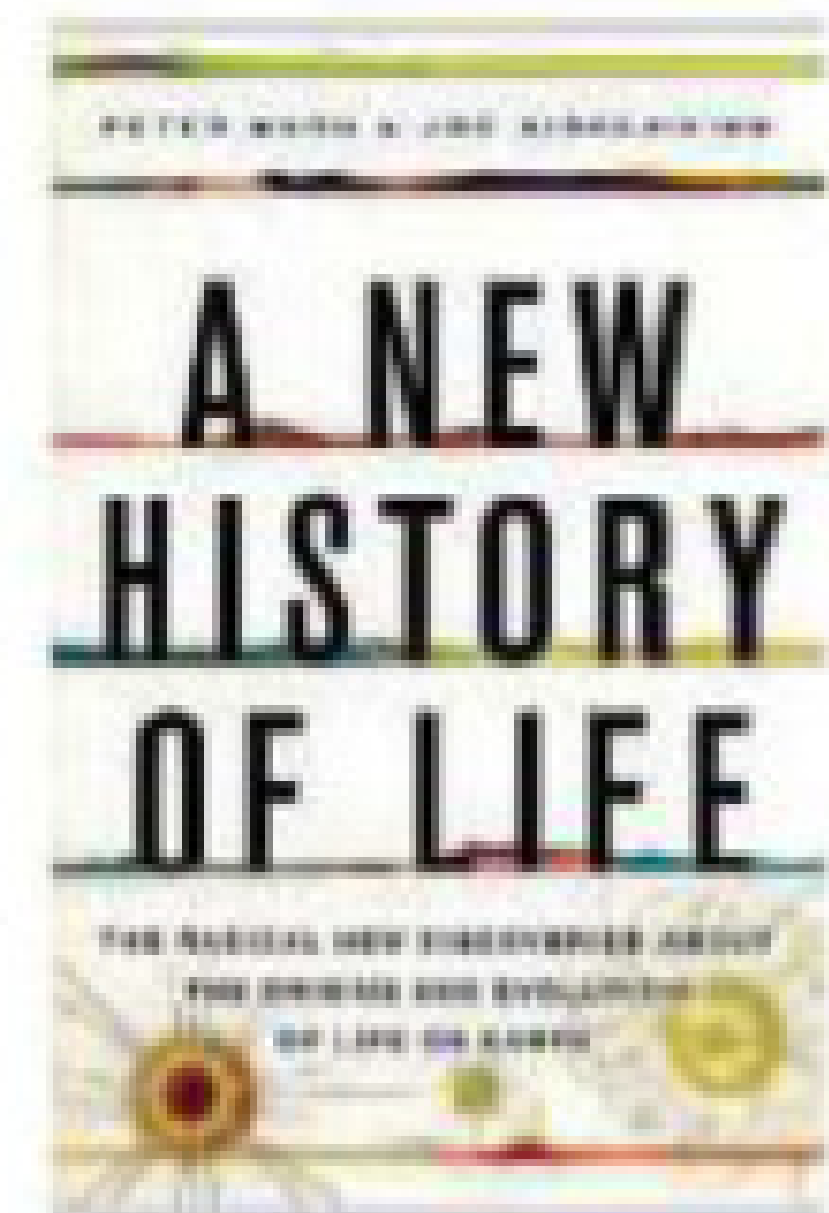
While STARnet and projects like it search to extend the success we have already known, perhaps the most likely driver of future progress is something we can't yet anticipate. "It will never end," Theis says. "We've explored a tiny fraction in terms of what is possible for computing." ■

Matthew Chalmers is a freelance writer based in Bristol, UK

The deepest danger

Hubristic humans refuse to accept that they are not extinction-proof, says **Jonathon Keats**

A New History of Life: The radical new discoveries about the origins and evolution of life on Earth
by Peter Ward and Joe Kirschvink,
Bloomsbury, \$30/£20



THE most brilliant innovation in the history of our planet was also the most catastrophic. Some 2.4 billion years ago, a microbe evolved to extract energy from sunlight. That chemical reaction exploited the abundance of carbon dioxide in Earth's early atmosphere. As greenhouse gas levels fell, our planet became a great snowball, enduring a mass extinction from which our young world barely recovered.

This cycle of boom and bust is typical of life on Earth. In fact, mass extinction is one of life's only constants, as Peter Ward and Joe Kirschvink show in *A New History of Life*. The other constant, counteracting life's destructive exuberance, is that "times of crisis promote new innovation". Each of us is "the descendant of survivors tempered by catastrophe and quenched by time", they say.

The two are well qualified to make such generalisations, and to take up the broader challenge of synthesising all that has happened since the first nucleic acids began replicating 4 billion years ago. Their interests and expertise are complementary. Ward is a palaeobiologist at the University of Washington, whose research and writing focuses on mass extinction; Kirschvink is the geobiologist at the California Institute of Technology responsible

for the Snowball Earth hypothesis. Moreover, a new history of life is much needed since the last grand synthesis, by palaeontologist Richard Fortey, was published in 1998.

As an update, Ward and Kirschvink's book is stimulating. Unfortunately, it is blighted by poor organisation and sloppy writing. Some of the same basic science is explained two or three times in different sections, and the prose seems rushed, making for a less-than-pleasant read. That said, *A New History of Life*

"Mass extinction is one of life's only constants, the other is that times of crisis promote new innovation"

is fascinating when the authors write about subjects close to their hearts, such as Snowball Earth.

That deep chill lasted over 100 million years, freezing the oceans and killing most organisms. One survivor was the cyanobacteria responsible for "inventing" photosynthesis and for the "great oxygenation event" that squandered atmospheric CO₂.

While the planet was frozen, the microbes bided their time in hot springs. As volcanism slowly replenished CO₂ and the greenhouse effect thawed out the great snowball, cyanobacteria flourished again, guzzling the precious CO₂ and snowballing the world for a second time.

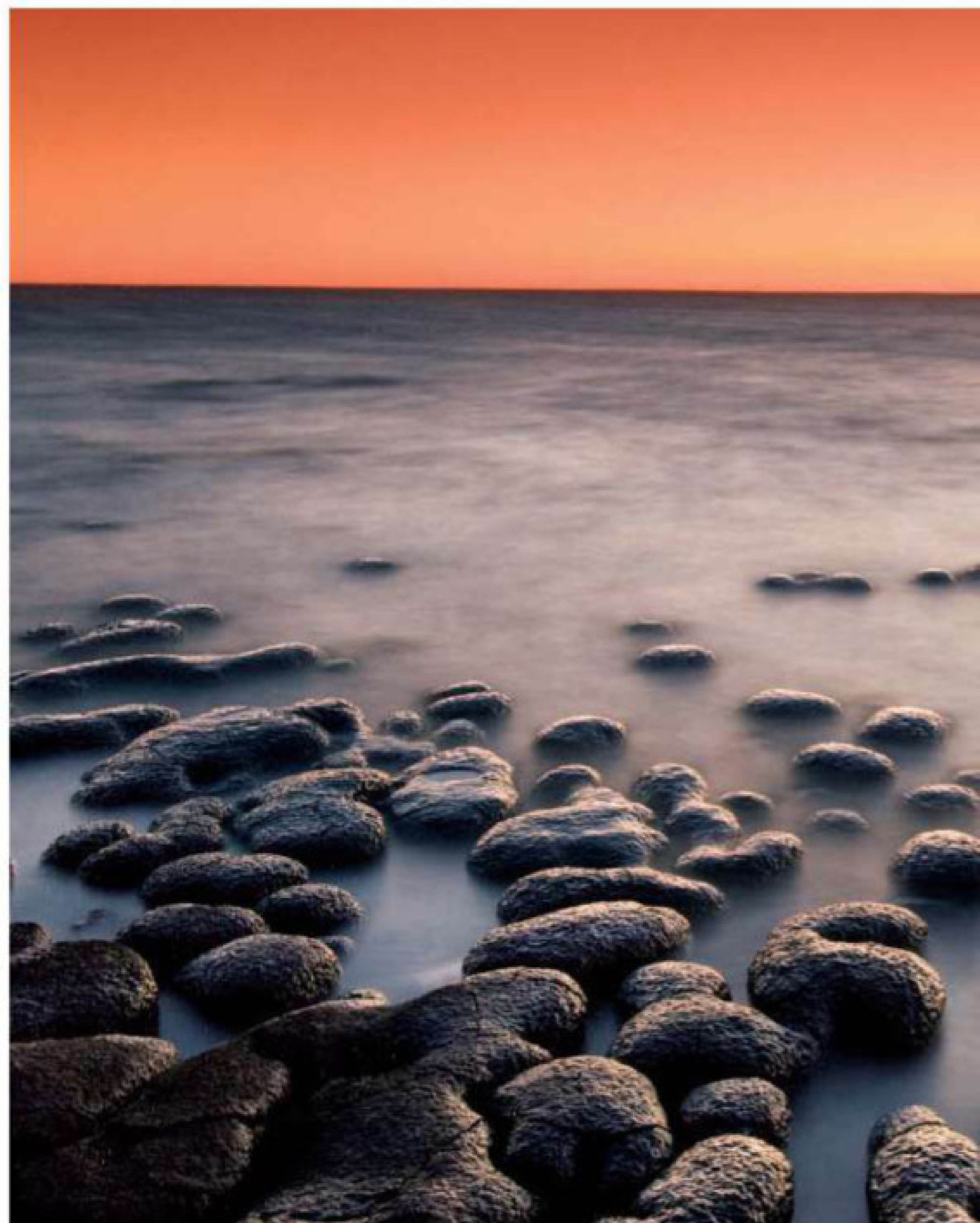
What extracted Earth from this vicious cycle, explain the authors, was the evolutionary enticement of oxygen: "Evolution would have immensely favored any organism that could use oxygen, since no other molecule lets the chemical

reactions we call life take place faster, with more precision, and liberate as much energy as those where oxygen is used."

The microbe that got oxygen metabolism right – mastering one of the most noxious of gases – became the basis of all animal life, subsisting inside every cell as mitochondria. By a similar process, cyanobacteria evolved into the photosynthetic chloroplasts inside plants. Evolution channelled crisis into

opportunity, ultimately allowing for the multicellular complexity of forests and people. Snowball Earth episodes offer a perfect example of how perversely creative mass extinction can be.

Yet once we were on oxygen, there was no kicking the habit. Nearly 2 billion years after the great oxygenation event, a precipitous drop in O₂ caused the greatest extinction of all time. Colloquially known as the Great Dying, the Permian extinction



eliminated 90 per cent of species on Earth. Purple sulphur bacteria suffocated the oceans, burping up toxic hydrogen sulphide gas. Atmospheric oxygen plummeted by two-thirds. Simultaneously surging greenhouse gas levels turned the climate tropical. As Ward and Kirschvink note, this rising heat increased the oxygen demands of animals at the worst possible moment. Many of the terrestrial species that didn't die took to the cooler seas. Largely abandoned, the land was wide open for any organism that could adapt. Dinosaurs made the leap.

The first crucial change was to go bipedal, allowing the reptiles to breathe while they walked. More

Shark Bay, Australia: cyanobacteria help form modern stromatolites



impressively, write Ward and Kirschvink, dinosaurs developed “the most sophisticated and efficient set of lungs... the world has ever seen”. Summarising research Ward first published in his 2006 book *Out of Thin Air*, the authors make a compelling case that these formidable lungs were decisive in the dinosaurs' ascent, at the expense of our mammalian ancestors. With a richer supply of O₂ in the low-oxygen Triassic, the reptiles simply had more energy, positioning them to dominate the Jurassic and Cretaceous.

But the dinosaurs could not survive the aftermath of a major asteroid impact. Darkened skies killed the vegetation that fed their massive bodies, leaving the world to scrappy mammals. “Sooner or later,” say the authors, “evolution, competition, and the natural changing of our Earth and sun as they age will make any body plan obsolete.” No advance is absolute. Evolutionary innovation is only as good as its fitness for a niche.

There is much to learn from Ward and Kirschvink's dinosaurs and cyanobacteria. As they note, “scientific information from

“Dinosaurs developed the most sophisticated and efficient set of lungs the world has ever seen”

so-called deep time is the single most ignored aspect of the climate change debate”. Earlier mass extinctions show us how radically the planet is altered by the balance of greenhouse gases and how sensitive life is to those changes. Yet the authors seem oblivious to deep time's deepest lesson when they claim humans are “pretty extinction-proof”, that somehow we are exempted from obsolescence by our superior intelligence.

The strength of most species is also their weakness. Ours, clearly, is hubris. ■

Jonathon Keats is an experimental philosopher and a conceptual artist



NATIONAL GEOGRAPHIC CREATIVE

Lights, action...

We have a winner for our movie competition, picked by sci-fi writer Kim Stanley Robinson

HEARTY thanks to the hundreds of readers who sent in their movie ideas for our 2014 Christmas competition. We asked for short “elevator pitches” of movies that would raise the bar for science-flavoured filmmaking, from documentaries to sci-fi blockbusters.

Since then we have been pelted with planet-destroying asteroids, experimented on by sinister Big Pharma and assailed by a plethora of physics experiments gone bad. When it comes to dreaming up wild ideas, *New Scientist* readers clearly eat a great deal of cheese before bedtime.

Award-winning sci-fi writer Kim Stanley Robinson has picked his favourites, and Matt Wilkinson is our proud winner. He will work on *The Sky Runner*, his story set on Europa, helped by industry professionals such as Christopher Priest, Liz Jensen and Louis Savy.

Robinson praised *The Sky Runner* for its visual potential, its strange technology and even stranger backstory, as it describes a submarine settlement's rediscovery of its place in the cosmos.

Runners-up Richard Fray, Guy

Dauncey, Simon Young, Dayne Thompson and David Oldcorn all receive a copy of *Flicker: Your brain on movies*, psychologist Jeffrey Zacks's new book about what happens in your brain when the lights go out in the cinema.

The competition was close. Fray's *Read/Write/Execute*, about what happens when we can edit memories, garnered comparisons to Philip K. Dick, and Thompson's *Orrorin*, about a present where several hominids coexist, triggered a lively debate over how easy it would be to tell them apart.

Then there was Young's take on the birth of modern zoology, *The Cuvier Debate*, which ably showed that cleverly reimagined historical fact can prove stranger than any fiction. And imagined present-day events at CERN's Large Hadron Collider set two winning entries rolling. Oldcorn's *Postponing Fermi* made a chilling but logical adventure out of exotic physics, while *Hope's Sisters* by Dauncey caught our judge's eye for its exploration of alternate futures.

We thoroughly enjoyed judging this competition. Let us know what you would like to see in future competitions. ■

Postdoctoral Insider Feature



A. JAMES CLARK
SCHOOL OF ENGINEERING

PROFESSOR AND CHAIR THE FISCHELL DEPARTMENT OF BIOENGINEERING UNIVERSITY OF MARYLAND, COLLEGE PARK

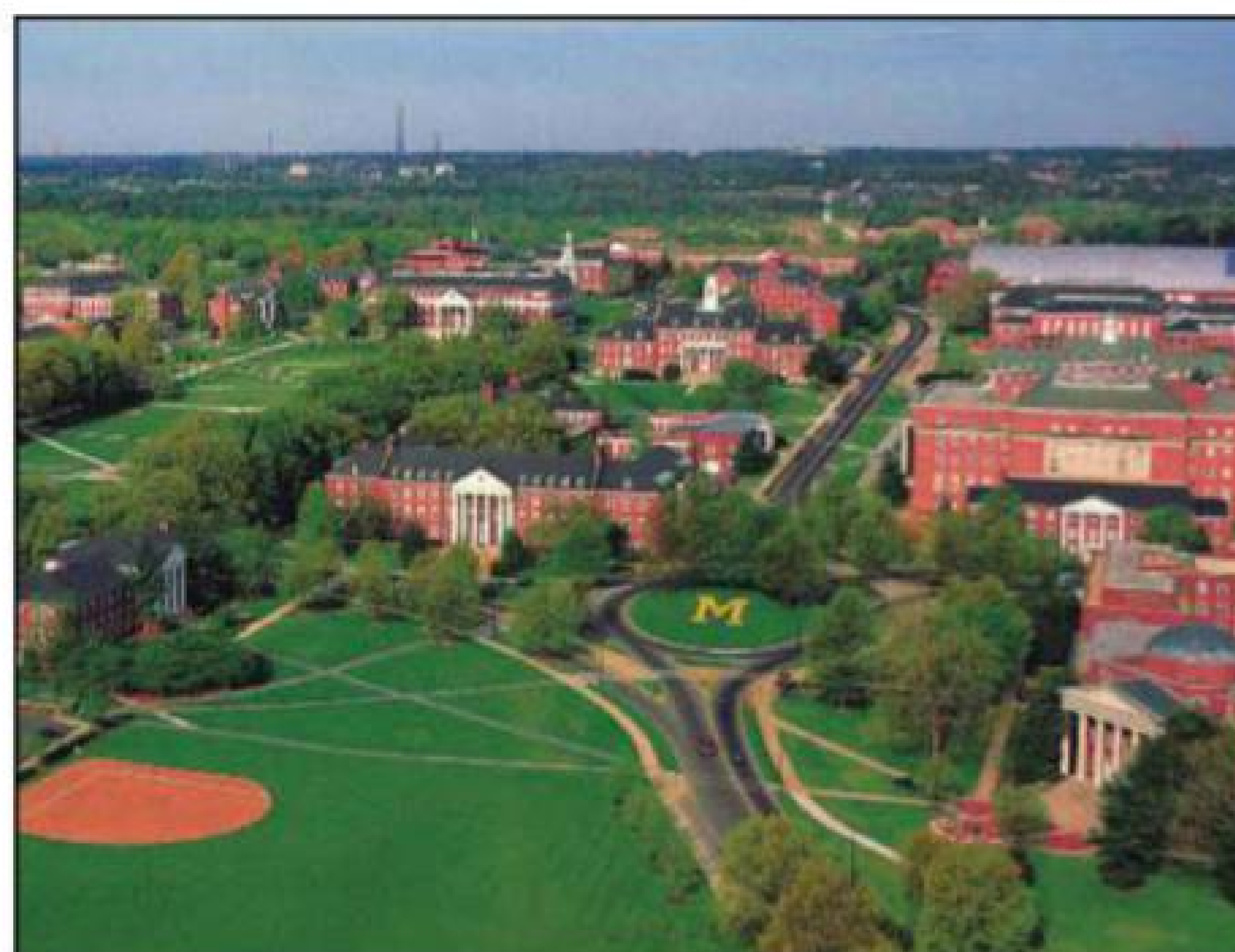
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In 2017, the Fischell Department of Bioengineering will move into A. James Clark Hall. This 184,000-square-foot building will house world-class research and educational facilities and the Robert E. Fischell Institute for Biomedical Devices <http://www.eng.umd.edu/clarkhall/>. The Fischell Department of Bioengineering

currently has 20 regular faculty (with plans to expand), 17 affiliate faculty members and 9 staff members, 400+ undergraduate students, 75 graduate students and more than \$8 million in annual research expenditures. More information at: <http://www.bioe.umd.edu>. Questions can be addressed to: Chair-SearchComm-BIOE@umd.edu.

For best consideration, applications should be submitted to <http://ejobs.umd.edu/postings/30410> (Position number 105571) by 1/30/2015. Applications should include a cover letter, complete curriculum vitae (resume), and contact information for five references.

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For more information about our programs, contact Aimee Doe, Program Coordinator, at Aimee_Doe@hms.harvard.edu



Assistant Professor Faculty Position

University of Pittsburgh Cancer Institute
and University of Pittsburgh

Department of Pharmacology & Chemical Biology



Applications are invited for a tenure-stream Assistant Professor-level faculty position at the University of Pittsburgh Cancer Institute (UPCI), specifically a PhD scientist working in the area of breast cancer biology, prevention and/or treatment. The incumbent will have primary appointment in the Department of Pharmacology & Chemical Biology, University of Pittsburgh.

The University of Pittsburgh, School of Medicine ranks among the top 10 NIH-funded academic medical centers, and the department is consistently one of the top 10 NIH-funded Departments of Pharmacology. At UPCI, faculty and lab personnel have access to state-of-the-art shared facilities with animal care, microscopy, mass spectrometry, high throughput drug discovery, translational research and clinical pharmacology analytical capabilities. The UPCI laboratories and shared resources are located in the Hillman Cancer Center and Magee-Womens Research Institute.

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Applicants should provide a one-page statement of research objectives, curriculum vitae, and contact information for three professional references to:

Dr. Maryann Donovan, PhD, MPH
Associate Director for Research Administration, UPCI
C/O Lola Thompson
5150 Centre Avenue, Suite 532
Pittsburgh, PA 15232
Email: thompsonla3@upmc.edu

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KANSAS STATE UNIVERSITY

POSTDOCTORAL RESEARCH ASSOCIATE KANSAS STATE UNIVERSITY DEPARTMENT OF PHYSICS

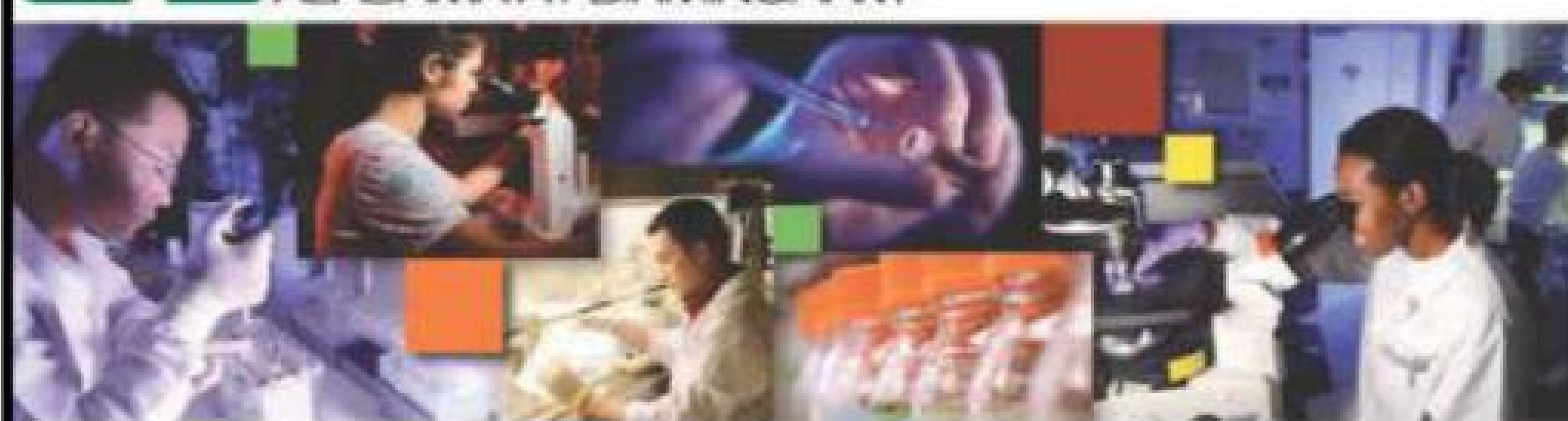
The experimental high-energy physics group at Kansas State University invites applications for a postdoctoral research associate position on the MicroBooNE and Mu2e experiments at Fermilab. The KSU group has a strong background in neutrino physics and is initiating a program in new physics searches at Mu2e. The group has significant instrumentation involvement in both experiments.

Candidates must have a Ph.D. in experimental particle physics by the date of appointment and research experience in high-energy physics data analysis. Experience in hardware is also preferred. The successful candidate is expected to be able to perform independent particle physics research, and play a significant role in detector construction activities and detector operations.

Interested candidates should send electronically to the HEP Search Committee, hepsearch@phys.ksu.edu, a statement of research interests, a curriculum vita with publication list, and three letters of recommendation e-mailed directly from the referees. Screening will begin on March 15, 2015, and will continue until the position is filled. For inquiries about the position, please contact Profs. Tim Bolton (tbolton@ksu.edu) and Glenn Horton-Smith (gahs@ksu.edu).

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UAB is recruiting candidates for postdoctoral positions in a variety of research areas. UAB faculty are well funded (top 25 in NIH funding), utilize multidisciplinary approaches, and provide excellent research training environments that can lead exceptional candidates to entry level positions in academia, government or the private sector. Full medical coverage (single or family), competitive salaries/stipends, sick leave, vacation, and maternity/paternity leave are offered with every position as well as AD&D, disability & life insurance. Depending on the source of funding, retirement benefits may also be available. Birmingham is a mid-size city centrally located in the southeast near beaches and mountains and enjoys a moderate climate for year round outdoor activities and a cost of living rate lower than most metropolitan areas.

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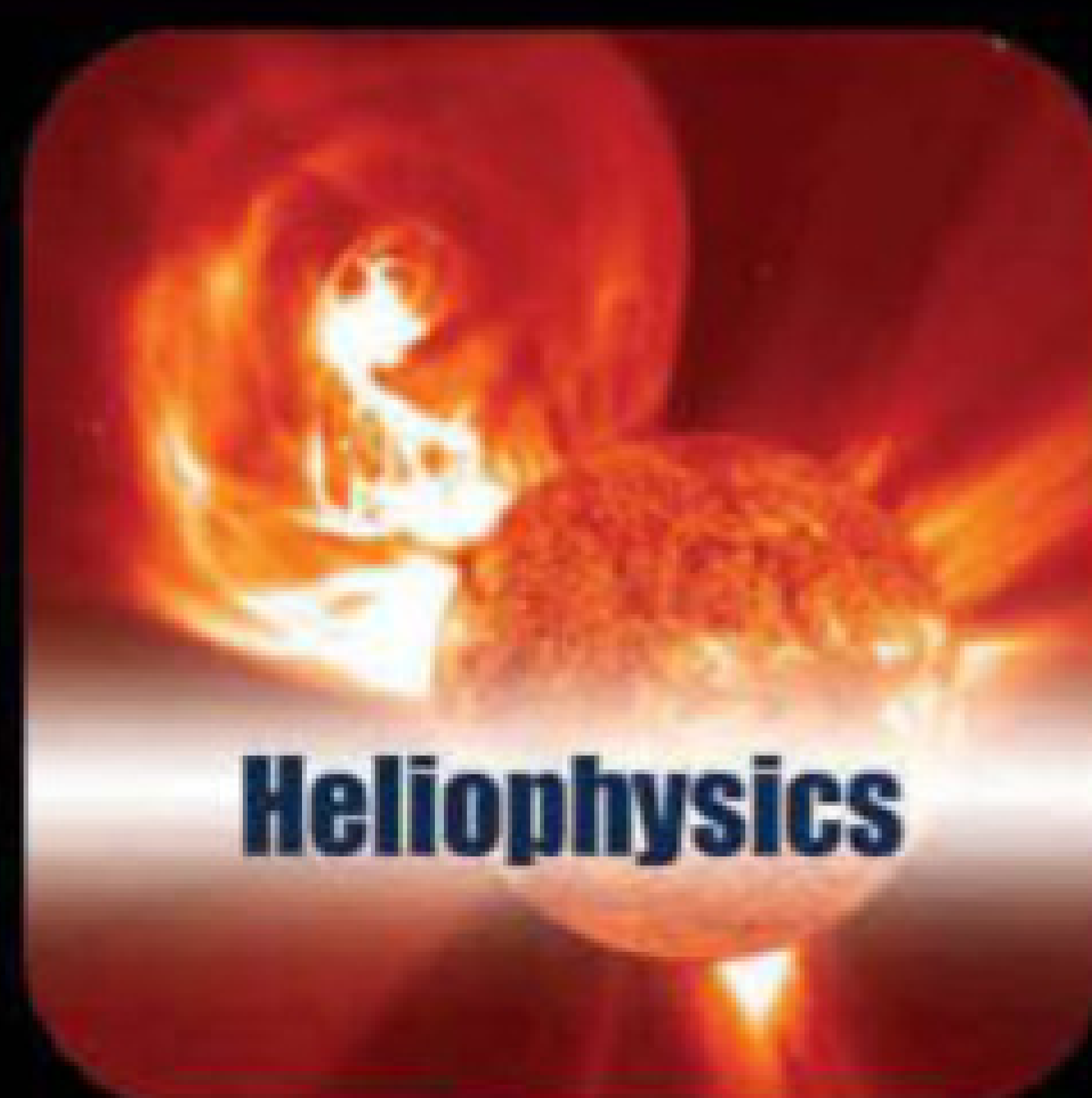
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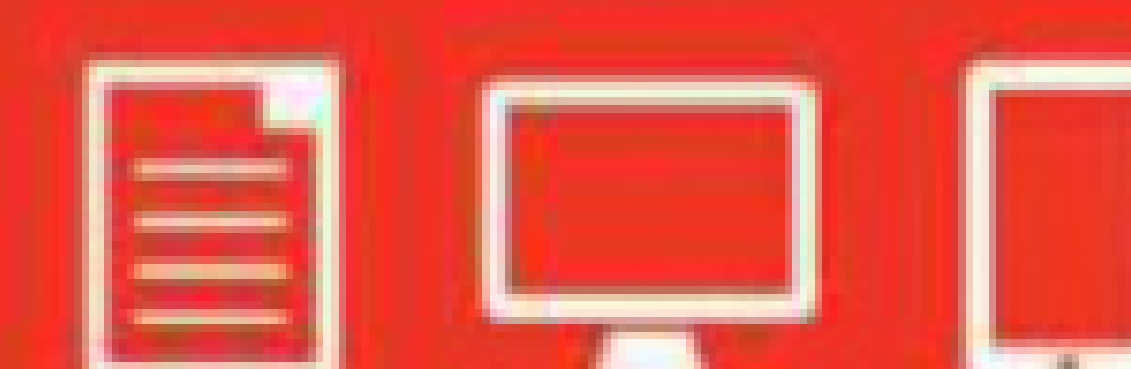
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Vitaly Klyachko, PhD
Assistant Professor
Department of Biomedical Engineering
Department of Cell Biology and Physiology
Washington University School of Medicine
E-mail: klyachko@wustl.edu
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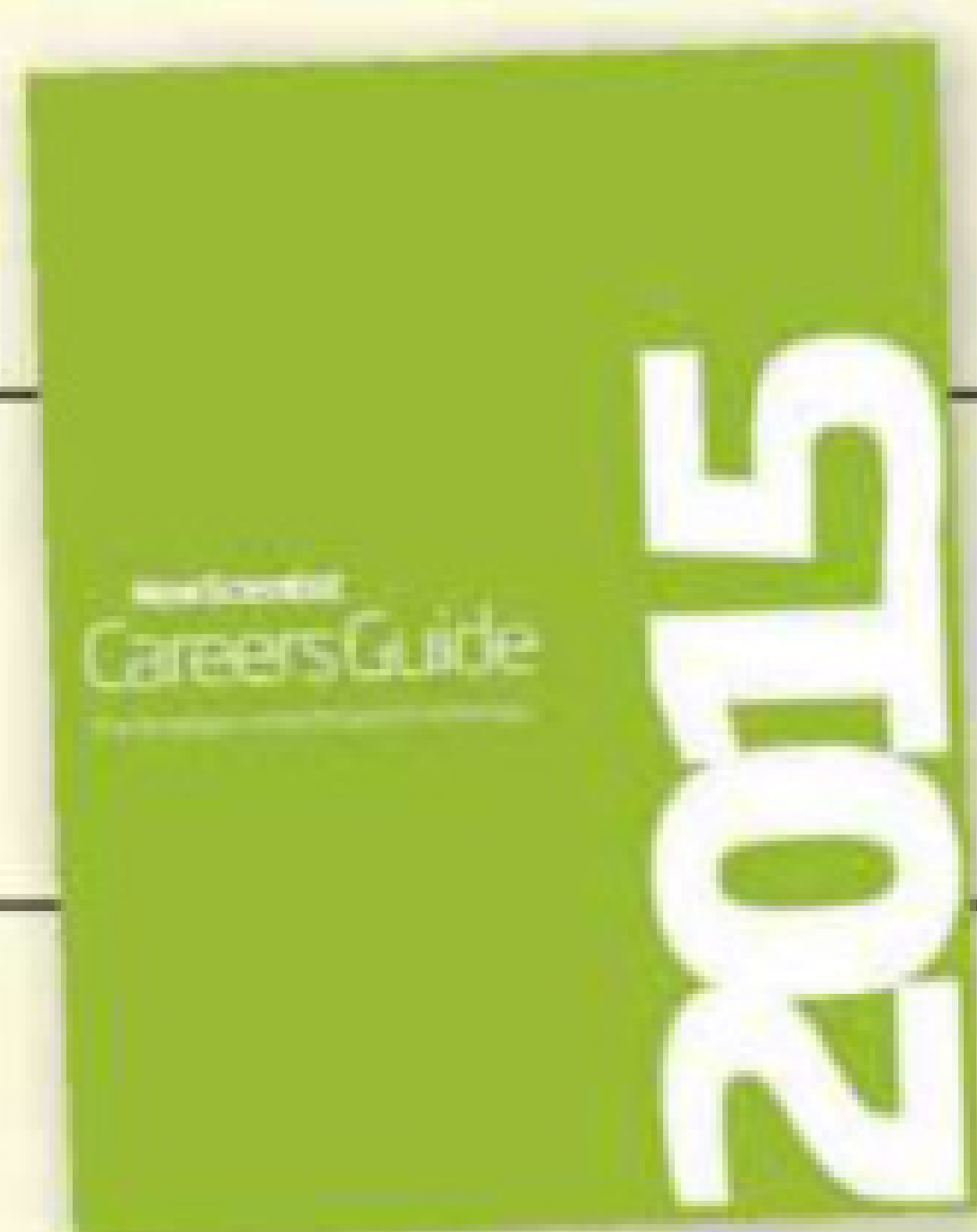
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Faith in the evidence

From Steven Miles

I was agreeing with E.O. Wilson (24 January, p 28) until he said: "I'm not an atheist – I'm a scientist. Atheism is the belief that there is no god."

Most atheists, including myself, say there is no god not because of whim but because in thousands of years of philosophising there has never been proof otherwise. True scientists would not accept such a major axiom without proof.

Also, we don't want to conquer anyone, as Wilson claims. People can believe any crazy thing they want. The atheist organisations that I belong to just want to keep religion out of the realm of government and stop the US from turning into a theocracy. Also, it would be nice if they paid their fair share of taxes.

Agnosticism is an untenable position and just shows that one is afraid of the word "atheist" because religions have denigrated it for centuries.

Having observed for myself how humans treat each other and the environment, if some god were to present itself, I might accept its existence but I would not worship it.

Gainesville, Florida, US

From Mike Paterson

Wilson blames religions for our overstretching of the world's capacity to sustain life. There's a more direct link, I'd suggest, with the insatiable greed encouraged by an economy that pillages any resource that will turn a profit.

Most religions have tried to teach the moral vacuity of greed as an approach to life.

Tamworth, Ontario, Canada

Coders culpable

From John Davenport

In discussing the impact of computer algorithms, we run the risk of turning them into scapegoats (7 February, p 30). But

all algorithms have their origins in human thoughts and decisions.

In principle it's a simple four-stage process: define a clear end result; decide on inputs and processes to achieve this end; assemble the appropriate computer language commands; and finally, check and debug.

The first two are under our control, and so it should be possible to make sure that they're working as intended and make common-sense changes where needed. We've all seen examples of user-unfriendly programs which must have been written by the unthinking.

Kenley, Surrey, UK

From John Dobson

In your leader on algorithms, you write that the AL in HAL – the name of the unhinged computer in *2001: A Space Odyssey* – is a contraction of "algorithmic" (7 February, p 5). That may be so, but very shortly after the film was released, someone pointed out that the letters in "HAL" come immediately before those in "IBM" in the alphabet. Which came first, I wonder, the contraction or the alphabetical dislocation? I think I know.

Allendale, Northumberland, UK

Flipping the bird

From John Hudson

You report that the lead bird in the V-formation of northern bald ibises "often swaps places with the bird behind it" (7 February, p 16). But surely there are two birds behind it, on either side.

My wife and I have a theory that the three birds in the triangle at the head of the V rotate places in three steps, so that each of them has one turn at the front and two spells second in line, one on the left phalanx and then one on the right.

Nottingham, UK

The editor replies:

Bernhard Voelkl's research only

found that the birds formed pairs which took turns flying in front, regardless of where they were in the formation originally. How the workload is shared at the front of the V is still an open question.

ET snubs broadband

From Adrian Ellis

In your article on a new strategy for those involved in the search for extraterrestrial intelligence (SETI), David Messerschmitt says that alien civilisations would logically choose to send short, wide-band radio signals rather than prolonged narrow-band ones, to improve both energy efficiency and bandwidth (31 January, p 17).



Yet probably the most important signal so far detected by SETI is the narrow-band "Wow!" signal, picked up in 1977. It came from the direction of Sagittarius and was almost exactly on the hydrogen line, a frequency many thought would be ideal for interstellar transmission. Should we tell the alien civilisation in Sagittarius that they're being a bit primitive?

Hampton, Middlesex, UK

From John Bailey

Travis Metcalfe believes that because rocky planets could have developed very early in the life of the galaxy, planets with advanced civilisations should be everywhere (31 January, p 13). The operative word here is "should".

This brings us back to Enrico Fermi's plaintive question: "Where is everybody?" If the galaxy is saturated with advanced civilisations, their heat signatures would be unmistakable, never mind whether we can hear or see them communicating with each other, and we would be knee-deep in self-replicating space probes spreading virally from planet to planet.

This discovery probably means there isn't anybody more advanced out there.

Canvey Island, Essex, UK

Plastic promise

From Alan Flavelle

Although Christina Reed portrays the grim side of plastics, there is hope with new biodegradable materials on the horizon (31 January, p 28).

It has been known for a long time that biodegradable alternatives exist; the main problem is the cost of the chemicals needed to make them.

Many of the big users of plastic bottles use plant matter rather than petrochemicals as their raw materials. Even so, the end product is chemically indistinguishable from petrochemical-derived plastic and is not biodegradable.

I am part of a group developing a process called oxidative hydrothermal dissolution, which, when applied to coal, produces chemicals which are precursors for making biodegradable plastic. If we succeed, we'll produce biodegradable plastic indistinguishable from types currently used, with the bonus of keeping it inexpensive.

West Perth, Western Australia

Glasgow fraying

From Bryn Glover

I am not sure if Jan Karpinski is being condescending or has simply missed the point in

claiming that de-industrialisation is not the source of Glasgow's enduring health and social problems (7 February, p 54).

Shipbuilding and steel making in Glasgow were certainly physically hard as Karpinski writes. They also brought workers a living wage. When those industries closed down, many thousands of families were abruptly flung into poverty, and the adverse effects of poverty on health are well documented.

Perhaps human society is classless in leafy country areas like Somerset in western England, but in big conurbations like Glasgow, it certainly is not. Nor is the city a singular entity as Karpinski seems to believe.

It is a city of many thousands of people who occupy very different strata in our unequal society, and who are either flying high as the city recasts itself as a tourist and international sports venue, or who are still struggling to survive after having their livelihoods kicked away from under them.

Glasshouses, North Yorkshire, UK

Do mitochondria, too

From Charles Sawyer

I hope that Maria Bitner-Glindzicz is including mitochondrial DNA in her project to collect 100,000 genomes to gain insights into disease (24 January, p 27).

A rare mitochondrial mutation has changed the course of my life, making me uncomfortably warm most of the time. I can usually spot others with this condition by their damp clothing or scanty attire, which during winter weather often invites the question, "Aren't you cold?"

Mitochondrial mutations do not necessarily kill, and may improve the quality of life. Let us not ignore them.

Byron Bay, New South Wales, Australia

The editor replies:

Bitner-Glindzicz has confirmed

that the project will be able to examine mitochondrial DNA in those with rare diseases.

Groupthink for all

From Peter Standen

In describing rituals as rigid, arbitrary behaviours that are tangential to achieving any practical goal, Dan Jones reminded me that they are not confined to African tribes, descendants of Vikings, or children (17 January, p 36).

Sociologists have categorised much of the activity in large organisations as rituals designed to foster conformity and group identity, even in rational goal-driven organisations such as universities.

Having worked in one such institution, I found the arcane duties prescribed by the Brazilian *simpatia* oddly familiar.

Darlington, Western Australia



Beaver fever

From Adrian Jones

Colin Bargery remarks on the perceived risk of catching a tapeworm from beavers (3 January, p 55).

Here in Canada, tapeworms are not considered a threat from beavers, unlike "beaver fever" – a colloquial name for the disease giardiasis. It is caused by the protozoan parasite *Giardia lamblia*, carried by beavers and muskrats. The protozoa live happily in fresh water, and can

colonise human water supplies, so stringent purification is required to get rid of them.

Banff, a famous mountain resort in western Canada, got its water from what was considered a pristine mountain stream. It was provided without treatment, until the rate of "beaver fever" put off tourists. An expedition sent upstream discovered a beaver dam and high levels of *Giardia* in beaver faeces and in the water. The water is now treated.

Edmonton, Alberta, Canada

A yawn a minute

From Bruce Denness

Contagious yawning may indeed be sparked by the action of mirror neurons as Chris Good suggests (24 January, p 54). But perhaps there is more to it than that.

Maybe a triggering yawn merely implants the idea of yawning, which then sparks an urge to yawn. I need only think about yawning to set myself off, rather than having to see someone else yawn first. In fact, I yawned twice while writing this.

Whitwell, Isle of Wight, UK

Forever, quantified

From Alberte Larue

Fred Pearce writes that the clean-up of the UK's Sellafield nuclear reprocessing site is scheduled to end by 2120, in 105 years (24 January, p 8). This brings to mind a common saying here in France. It translates as "we are not going to wait for 107 years" – which is to say, we are not going to wait forever. The origin may have something to do with a long dispute between our countries.

Compiègne, France

Enemy combat ants

From Ian Service

I was interested to read Flora Graham's article about ants

tolerating other ants, as long as they were of a different size (newscientist.com/article/dn26872). This contrasts with behaviour I observed while living in Papua New Guinea.

Two species had encountered each other while foraging on a tree trunk. The black ants were



able to grasp one of the smaller brown ants in their mandibles and carry it away. Meanwhile, several of the brown ants could collectively pin down a black ant and drag it off. The battle line moved back and forth for many minutes before I moved on. No living in harmony for these two different-sized species.

Arnside, Carnforth, Cumbria, UK

Planck calls

From Martin Gregorie

Further to Vernon Barber's speculation (7 February, p 54), if we do turn out to be autonomous avatars in a computer simulation, then Planck's constant is the limit of the model's resolution.

Harlow, Essex, UK

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FURTHER to Feedback's report on competition between the blue whale and the double-decker bus as metaphorical masses (14 February), we delve into our piling system and wonder, not without pride, whether colleagues on other publications are competing for a mention here. Or is there another explanation for the proliferation of articles that make truly bizarre comparisons, apparently to help readers grasp quantities?

Ralph Platten sends an article from the *Aargauer Zeitung*, a Swiss newspaper, reporting that the extinct shark *Carcharocles megalodon* had the mass of a blue whale. Fair enough. But in case that wasn't enough, it expands with rare specificity: "or about 61 Ferrari F12 Berlinetta". Is this a reference to the paper's owner's wheels, or what?

CRAMMING the greatest possible number of metaphorical meta-units into one piece seems to be a pastime for some writers. Eddie Aitken sends an article from the *Daily Mail*, a newspaper, extolling

a jet engine from Rolls-Royce, a proud remnant of the UK's manufacturing base.

Its fan case is "wider than the fuselage of Concorde"; the fan can inhale "up to 1.3 tonnes (more than a squash court) of air every second"; each turbine blade generates as much power as "a Formula 1 racing car"; and "the force on a fan blade at take-off is... the same as nine London buses." What? No blue whales?

SHIPS, for some reason, attract multi-unit extravaganzas. We wondered whether an example from Bloomberg News, comparing the world's five largest ships to seven organisms and landmarks, was the result of a bet in the office (8 March 2014). James Madden sent a BBC News story about the floating gas-processing platform Prelude that managed to allude to football pitches, Eiffel Towers, Empire State Buildings and Sydney Opera Houses.

Now four readers alert us to descriptions of the Globe, which was

briefly the world's largest freighter. John Medhurst enumerated the metaphors in another BBC News story: Olympic swimming pools; London buses; pairs of shoes; tablet computers; tins of baked beans; "an office block lying on its side"; football pitches; and vacuum cleaners as a unit of power, nodding to European Union energy-saving regulations that set a ceiling for these. And, he laments, there was "not an elephant in sight". Then a message arrived from Leo Condon pointing us to the *Daily Telegraph* claiming, among other things, that the Globe can carry 955 million clementines; and the *Daily Mail*, that it can hold 900 million tins of baked beans.

One of these is wrong, unless each fruit has its own silken pillow. We know not which, but we suspect spoon-feeding by a public relations creature with a calculator and a quiet afternoon.

WE DO not claim that this august publication is exempt from metaphorical exuberance. Stephen Withall noted a report on how ants munch litter in New York (6 December 2014, p 15). Specifically, "about 60,000 hot dogs or 600,000 potato crisps in a year". "With the bread roll or without?" asks Stephen. And, either way, "surely even New York doesn't have crisps as large as 0.1 hot dogs?"

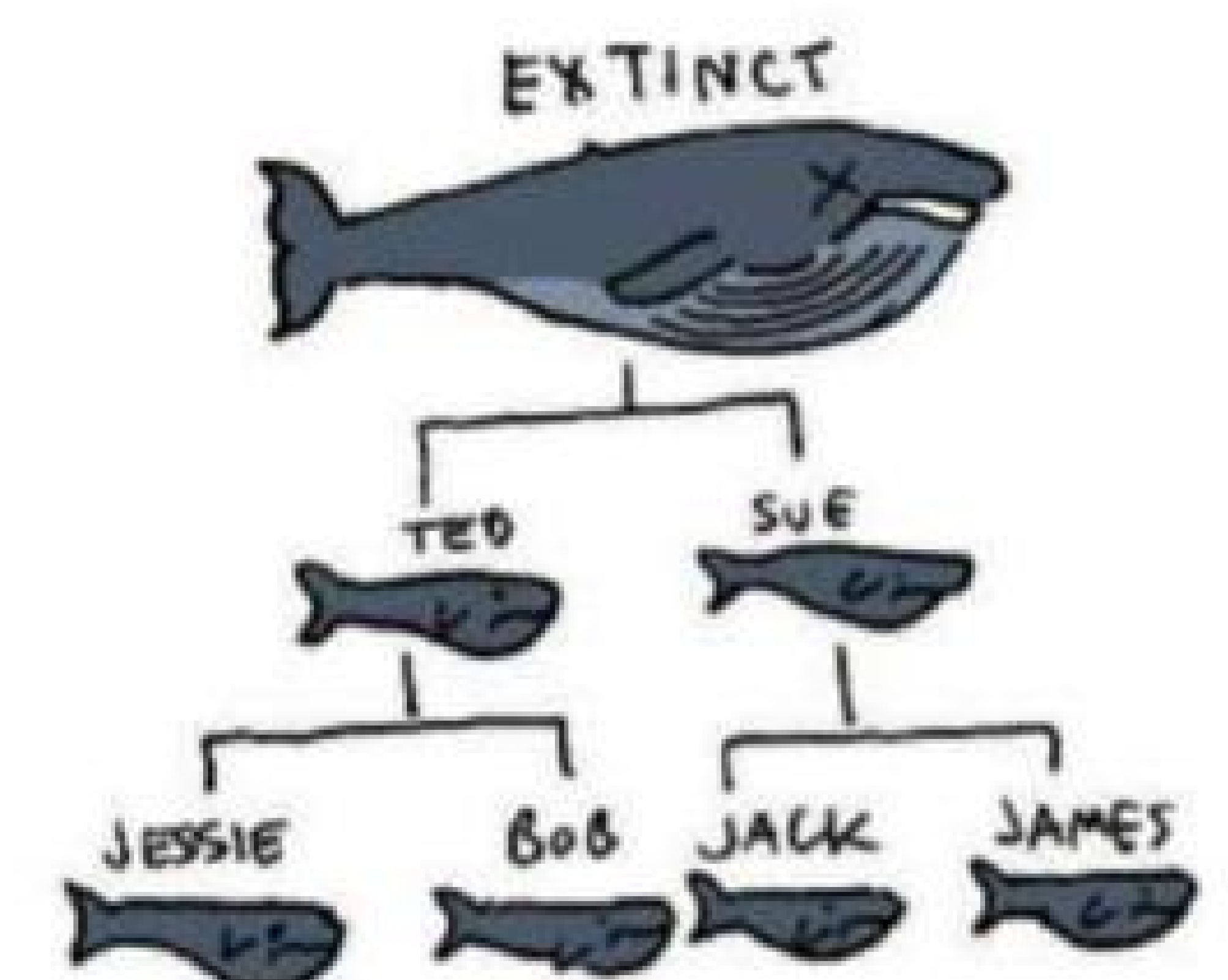
CRISPS may have appeared adjacent to error in this here column, too (24 January). Seven readers pointed, and some giggled, at the phrase "crispy fried slithers of male human" as an interpretation of "MAN CRISPS".

We rather hoped that our source had deliberately sneaked this past six pairs of editorial eyes to imply something slippery. Disappointingly, she meant "slivers". (The Oxford Dictionary does, however, accept her usage.) This episode thus confirms Grant Hutchison's suggestion of "a need for a word to designate the sort of spelling error that reveals a person's accent." Our source is indeed of Cockney extraction, and the usage does echo the orthography of London

novelist Charles Dickens. So what is this word to be? The words sound the same only under particular circumstances, so they're not homophones as in "which witch?". Hemihomophones or humophones?

MEANWHILE Andy Johnson-Laird requests a word for "words that are mis-parsed by our minds". He refers to "mishits", which he reads as "'mi-' followed by the rest of the word", and the website penisland.net (which in fact sells pens). Over to you...

A QUICK search of the US and EU trademark registers reveals no legal claims on use of the above-mentioned "penisland". Take care henceforth, however, when using "Tweet". The Twitter corporation's application to extend its protection in the EU to more than 750 contexts (3 January) was granted on 5 February. If referring to "Tweet" in connection with pelisses, gabardines or religious meetings, you must now capitalise the word.



FINALLY, whales are more than metaphorical units – they breed philosophical puzzles too. Phillip Clapham sends a translation – not necessarily much touched by the human hand – of a Japanese *Sankei News* editorial. It refers to "a slow increase in the number of extinct blue whales".

Feedback now wants an Aspirin™ and a cold drink.

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Marketing and arithmetic: not happy together. Tony Richey wonders how Domino's Pizza's offer of "savings of up to & over £350" means more than "savings"

Off colour

I spotted this blackbird (see photo) in the garden. It is not black but light grey, and it did not have pink eyes so I guess it is not an albino. It spread its wings and lay in the sun; in due course it flew off. I've never seen a blackbird with this colouring before. Can anyone tell me more about it?



■ I am curator of the Bird Group at the British Natural History Museum, and heritable colour aberration in birds has been my main research area for the past 15 years. During that time, I have learned that the identification and naming of colour aberrations still present a problem in the ornithological world.

The main reason for this is, probably, that the appearance of similar aberrations, which are caused by genetic mutations, can differ radically between birds of different species depending on their original pigmentation. It also varies with sex and age. This, plus the fact that a bird might be too far away or moving too quickly to see clearly, often makes it hard to distinguish between different aberrations.

A variety of names are used, seemingly at random, to identify the mutations. The terms albino and partial albino are the most commonly applied, and are most frequently wrong.

Your questioner correctly assumed the bird is not an albino because it does not have pink eyes. However, even without seeing the eyes you can tell this bird is not an

albino because it is grey and therefore has some melanin pigment. Animals with the genetic mutation that causes albinism cannot produce any melanin because the enzyme tyrosinase is absent in the pigment cells. So there is, in fact, no such thing as a partial albino.

This blackbird's grey plumage is the result of an aberration called dilution. From the Latin *dilutor*, meaning paler or weaker, dilution can be defined as a reduction of melanins. The number of pigment granules is reduced but the pigment itself is not changed.

The lower concentration of granules forms a weaker, or diluted, colour. This is analogous to a black-and-white photograph in a newspaper: a high concentration of black ink dots close together is perceived as black, while fewer black dots in a similarly sized area appears grey.

Hein van Grouw
Tring, Hertfordshire, UK

Head lines

I have noticed that my head is tilted to my right in most photos, even though at the time the photos were taken, I believed my head to be erect. If I move my head to be upright, I feel as though it is tilted to the left. I am strongly right-handed. What causes this delusion, and is it common?

■ As an occupational therapist, I have seen many people who have had strokes subsequently lean their head and even their entire body to their unaffected, stronger side. Many people who have not had strokes also have a tendency to lean a little.

There are two factors at play here. First, the brain adapts to conditions. After leaning slightly for a period of time, the brain accepts this condition as normal and perceives the body to be upright.

Second, very right-dominant people use their right arm and hand more than their left, so they develop strength and muscle tension more on that side. Increased strength and tension in the upper trapezius and levator scapulae muscles, which connect the shoulder girdle to the head, can cause the head to tilt to the right, and the brain would soon adapt to accept this position as upright.

Bonnie Clancy
Fort Myers, Florida, US

■ There may be an anatomical explanation for your questioner's head tilt. Our son was diagnosed

at age 13 as having a rare anomaly of his C1 vertebra; it is open in the front and has a floating piece of bone instead of part of the left side. The anomaly was discovered in a neck X-ray, while neurologists looked for the cause of two strokes he had.

They suspected the problem was in his neck because, prior to the discovery, physical therapists often coached him to hold his head straight. Photos of him as a baby and young child reinforced their hunch: he had always held his head tilted to the left. The paediatric cervical spine specialist later confirmed that the C1 anomaly would cause a tip in the angle at which he holds his head.

The anomaly had indirectly caused his strokes by repetitively injuring his left vertebral artery. He has made a full recovery through time, hard work and a titanium microcoil implanted to protect the affected artery. Your correspondent's experience may be "a delusion", but evaluation by a spine specialist might be recommended.

Nancy Benz
Ramsey, Minnesota, US

This week's question

HISSESSSSSS

How long do I have to wait after dropping a beer bottle before I can safely present it to a guest, and how did its internal pressure build up if the system is in equilibrium?

Robert Volpe
Highton, Victoria, Australia

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